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Mathematics a Tool

I ATTENDED a meeting of engineers recently—practical engineers—and one of the speakers told of a man who got a job in a power plant. He was a great mathematician, could figure anything, but he bungled in filling a lubricator one day, showered the boss with cylinder oil and got fired.

If he had put his mind to filling oil cups and similar operations, he might be filling oil cups and wiping up machinery today for a small stipend. If he really was a good mathematician and knew how to apply his mathematics, he might be filling an agreeable position and collecting dollars instead of dimes.

Mathematics is simply a tool. The man who can handle it has a valuable asset, but it will do him no good if he does not make intelligent use of it. The ability to read gives a man who possesses it a great advantage, but if he uses this ability in reading trashy literature or even in reading and studying subjects a knowledge of which is of no practical use to him, to the neglect of those which would help him to success, his learning is a hindrance rather than a help.

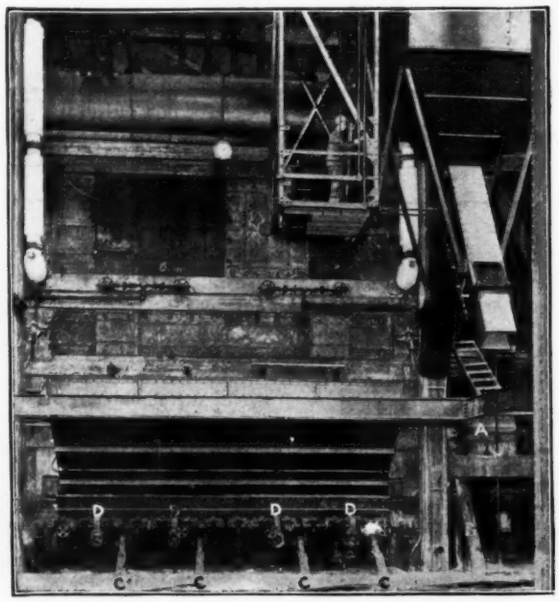
There are those to whom mathematics comes naturally. They learn readily the forms, rules and processes and can give you an answer to a complicated problem. They know how to use the tools, but they may not know how to lay out the job.

A man may be an excellent stone mason or carpenter, but utterly unable to lay out a cathedral or a house.

A knowledge of mathematics is very useful to an engineer. No man can be a great engineer without it. But he must first of all be an engineer. If he is, he will have problems that mathematics will help him to solve, and his ability to solve such problems will lead him into doing things—bigger and better things—than he would otherwise attempt.

It is nothing against mathematics that a good mathematician was a poor power-plant helper. There are a lot of good men in power plants who would be better men, holding larger jobs, if they knew more of mathematics. And when in the fullness of their years they learn how simple it is, how little exertion it would have required to have equipped themselves with all the mathematics that they needed, when they realize the uses they could have made of this knowledge and where it might have carried them, they will deprecate, as I do, the attitude of some of these severely practical men, who know it not, toward this useful tool of engineering.

F. R. Low



Hell Gate Boilers and Their Auxiliaries

THE May 2 issue of *Power* gave a general description of the new Hell Gate Power Station of the United Electric Light and Power Co., New York City. This article gives further details in regard to the boilers and boiler-room equipment. The present installation has two groups of apparatus each containing six 18,900-sq. ft., cross-drum water-tube boilers. These are equipped with 3-in. tubes and double-fired with underfeed stokers. All the boiler-room auxiliaries are driven by alternating-current motors, most of which operate at 2,200 volts. The hydraulic system of ash removal used in this station is of particular interest.

A DIAGRAMMATIC plan of the boiler and operating rooms of the new Hell Gate Station is shown in Fig. 1. The ultimate plant will contain eight main turbine units, totaling 300,000 kw., and twenty-four boilers. The present installation of four main turbines (totaling 150,000 kw.) and twelve boilers is located in the northern half of the plant, as shown in the plan by cross-sectioning. The equipment of the ultimate station will probably be divided into four similar groups, each of which will be practically an independent power plant of 75,000 kw. There are two of these groups in the present installation.

Group 1 (referring to Fig. 1) contains main generating units 1 and 2, house-turbine unit 1, boilers 11, 12, 13, 21, 22 and 23, and stack 1, together with a complete set of auxiliaries for these units. All of the boiler-room auxiliaries and most of the other station auxiliaries are motor-driven. The relation of these to the heat-balance system will be explained in a special article in the May 16 issue of *Power*.

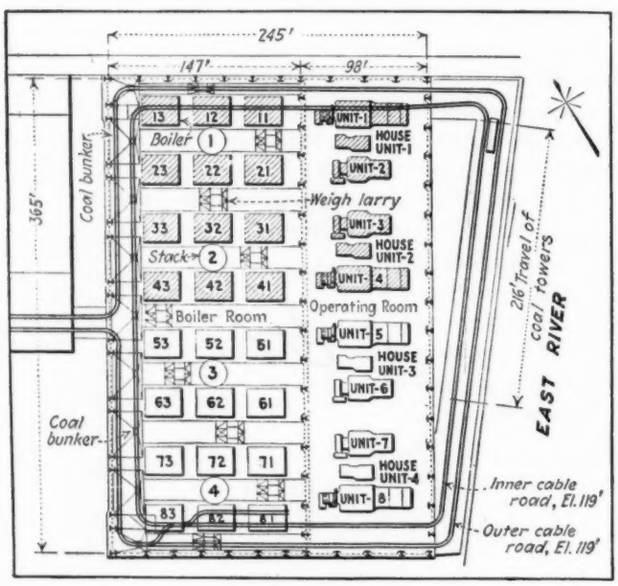


FIG. 1. DIAGRAMMATIC PLAN OF POWER PLANT (PRESENT UNITS INDICATED BY CROSS-SECTIONING)

The boiler room is constructed for the ultimate capacity. It is 365 ft. long (north and south), 147 ft. wide and 100 ft. high from firing-aisle floor to ceiling. The boiler-room basement is 25 ft. high. The nine (ultimate) firing aisles run east and west for the length of three boilers. Each is served by an individual weigh larry taking coal from a bunker at the west end of the aisle. In the two end aisles the bunkers are of 250-ton and the larries of 15-ton capacity, while the corresponding figures for the other seven aisles are 400 tons and 25 tons. This gives a total bunker capacity of 3,300 tons. The bunkers are supplied with coal by two overhead cable roads. Fig. 2 is a view looking east down the firing aisle between group 1 and group 2.

The steam piping of group 1 is shown diagrammatically in Fig. 9. Although this article is not concerned with the turbines as such, it should be noted that the steam for each main unit is normally supplied by the adjacent row of three boilers, although a cross-connection is provided. The house turbine and steam-driven auxiliaries may be supplied from either row of boilers or from both. Except for a motor-operated 18-in. valve, which is normally closed, there is no connection to the steam piping of group 2.

Fig. 3 is a cross-sectional view (looking west) through the first group of six boilers. The north firing aisle is on the right, while the coal bunkers are on the far side of the room. Two of the double-fired, cross-drum, sectional Springfield boilers are shown. In order to get a clear idea of the arrangement of the boiler tubes and the superheater, this section should be studied in connection with Fig. 5.

Each boiler has 18,900 sq.ft. of water-heating surface. 2,135 sq.ft. of superheater surface and a combustion volume of about 8,000 cu.ft. It is double-fired with underfeed stokers. The setting is high, the upper ends of the lowest row of tubes being 21 ft above the floor.

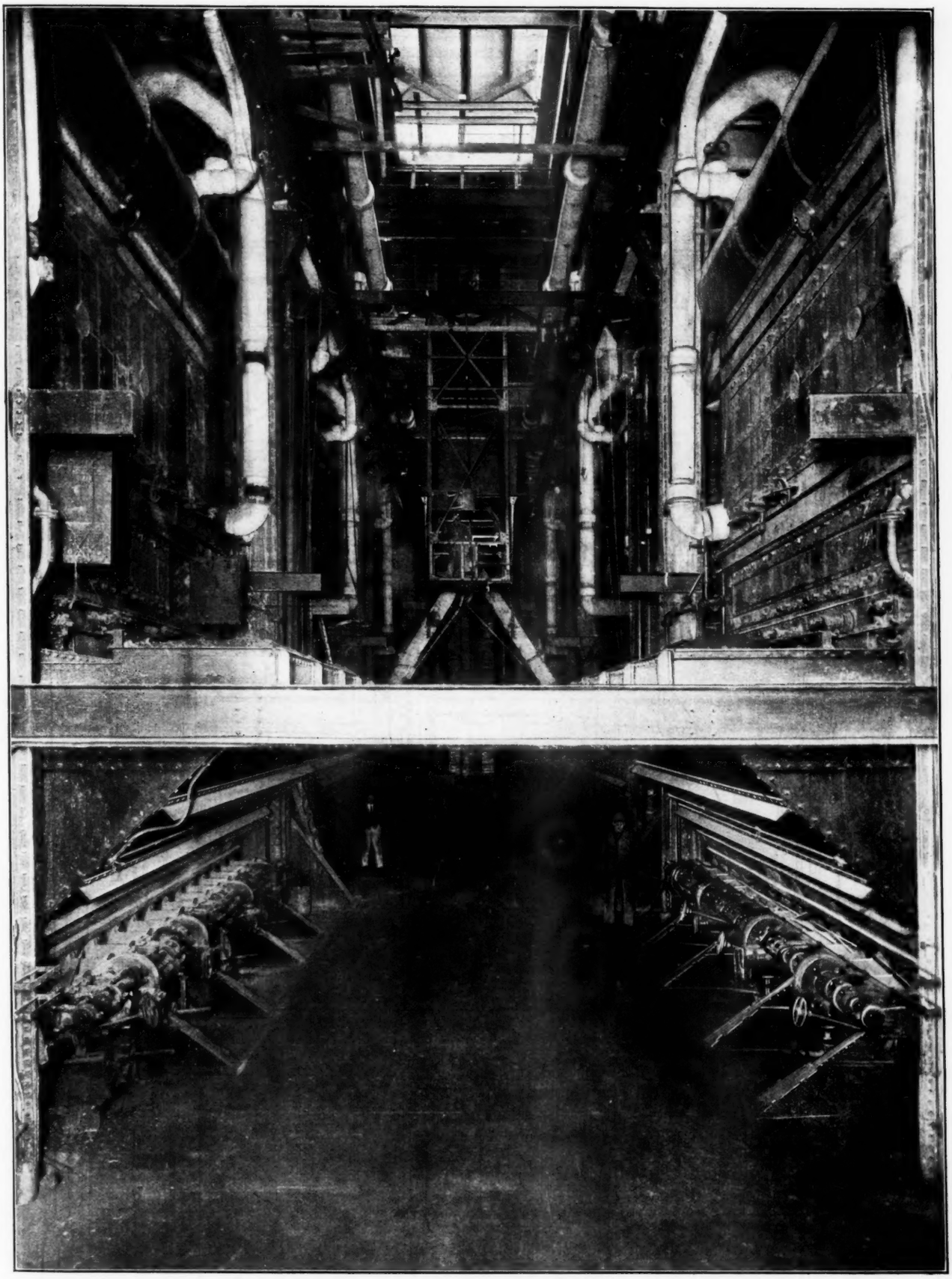


FIG. 2. VIEW LOOKING EAST DOWN FIRING AISLE BETWEEN THE FIRST AND SECOND GROUPS OF BOILERS

There are three 18,900-sq.ft. cross-drum sectional water-tube boilers on each side of this firing aisle. The total number is 12 for the present installation and 24 for the ultimate. Each boiler is double-fired with two 14-retort underfeed stokers and has 2,135 sq.ft. of superheating surface. The steam pressure is 250 lb. gage and the superheat 200 deg. The weigh larry carries 25 tons.

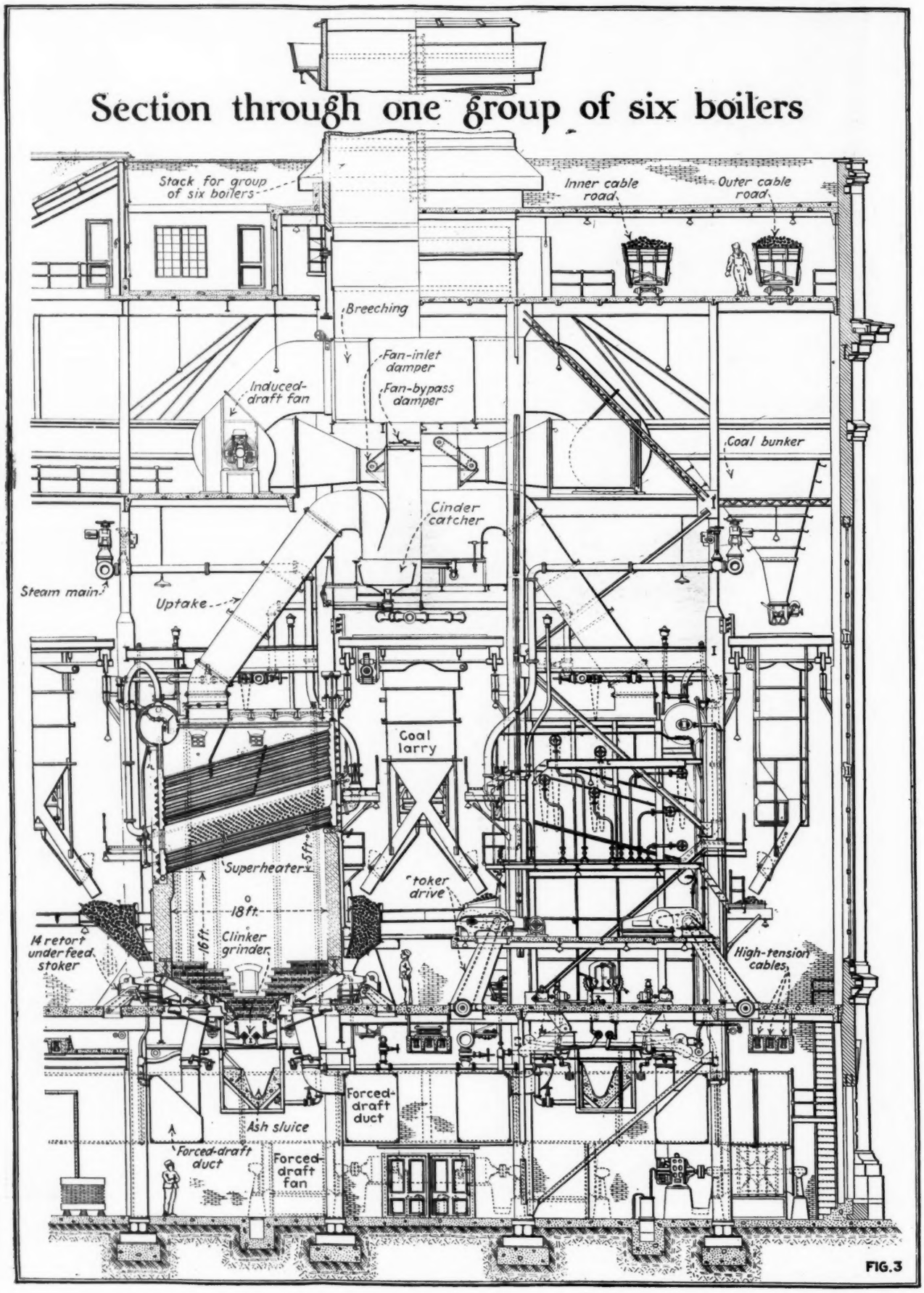

Section through one group of six boilers
Stack for group of six boilers
Inner cable road
Outer cable road
Breeching
Fan-inlet damper
Fan-bypass damper
Induced-draft fan
Coal bunker
Cinder catcher
Steam main
Uptake
Coal larry
Superheater
5ft.
18ft.
16ft.
Stoker drive
14 retort underfeed stoker
Clinker grinder
High-tension cables
Forced-draft duct
Ash sluice
Forced-draft duct
Forced-draft fan

FIG. 3

It will be noted that there are two sets of tube headers at each end of the boiler. The lower set contains the first six rows of tubes, the remaining fourteen rows being connected to the upper set. This "double-deck" construction gives a clear vertical space of 36 in. from the top of the sixth row of tubes to the bottom of the seventh. Part of this space is occupied by the superheater. The header sections are of steel and two tubes wide. They are of sinuous construction, rising vertically for two rows of tubes and then offsetting for the next two rows, which brings the first, second, fifth, sixth, etc., rows in one vertical line and third, fourth, etc., in another. This arrangement is clearly shown in Figs. 4 and 5. It should be noted that there is only one handhole for each group of four tubes (two wide and two high).

The boiler has a width of 54 tubes and half that number of header sections. This gives a total of 1,080 inclined tubes and 108 header sections. The inclined tubes are 3 in. in diameter, 20 ft. long and have a pitch of 15 deg. Each lower header section is connected to the corresponding upper section and each upper section to the single cross-drum (diameter 54 in., length 30 ft.) by a group of four 3-in. circulating tubes. The top handhole of the front header section, shown in Fig 4, is for one group of the horizontal circulating tubes. The use of sectional headers with pipe connections gives a flexible construction free from rivets and staybolts.

In large boilers recently erected it has been common practice to expose the first row or two of tubes to the radiant heat from the fire and the furnace walls. This serves the combined purpose of increasing the effectiveness of the heating surface and reducing the temperature of the brickwork. In the Hell Gate boilers these effects have been greatly increased by locating the horizontal portion of the first baffle above the eighth row of tubes.

Sectional Cast-Iron Baffles Used

The construction of the vertical baffles, as shown in Fig. 4, is of particular interest. They are made in sections, one for each set of header sections. Each baffle section is a one-piece frame of cast iron corresponding with the header in outline and in hole arrangement. The depressions in the frame are filled with refractory material. Any tube may be taken out without disturbing the baffles or other parts of the boiler.

As already mentioned, the setting is 21 ft. high and has approximately 8,000 cu.ft. of combustion space. The interior width, measured parallel with the firing aisles, is 25 ft., while the other dimension is 18 ft. No arches are used in the setting, either in or between the walls. The parts of the walls over the stokers are supported on heavy cast-iron beams protected by firebrick. Otherwise the walls are self-supporting, except that they are braced by vertical I-beams set in the outer brickwork and running from the floor of the boiler room to the top of the setting. Several vertical and horizontal expansion joints of special design are provided in each wall. A description of these joints, which represent a new departure in furnace design, is not available for publication at this time. The walls are constructed of 22 in. of firebrick backed by 4 in. of Sil-O-Cel insulating brick Outside of this is a quarter inch layer of asbestos millboard and a casing of No. 11 B.w.g. sheet steel. The lower part of the furnace is lined with non-clinkering, air-cooled Drake blocks. Air is supplied to these from the forced-draft ducts.

On each side of the boiler is a 14-retort, 17-tuyere, Type *AA*7, Taylor underfeed stoker. In this stoker each retort has two rams—an upper one for pushing in the green coal and a lower one, with adjustable stroke, for maintaining the proper fuel-bed contour. At the lower end of the tuyeres of each stoker is a slowly reciprocating extension plate that permits the carbon to be burned completely out of the ash before the latter falls into the open ash pocket. At the bottom of this pocket are two clinker-grinding rolls, the tops of which move outward, crushing the clinker against two hinged crusher plates.

The fineness of grinding is independently controlled for each roll by a hand wheel, which acts through a worm, wormwheel and link to set the crusher plate at any desired distance from the roll. The location of the clinker grinders at the bottom of a deep pocket gives ample opportunity for the ashes to cool and also provides a fairly tight air seal.

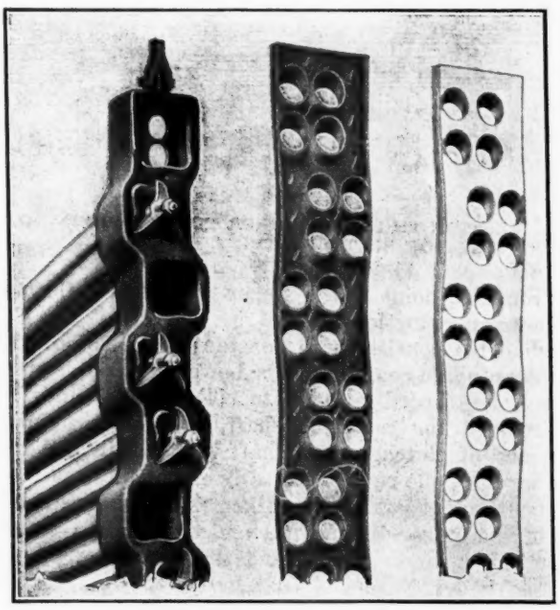


FIG. 4. HEADERS AND BAFFLES

Left—Portion of one of the upper header sections.
Center—One-piece, cast-iron baffle section.
Right—Baffle section after filling with refractory material.

Each of the two clinker-grinding rolls is independently driven by a two-speed 10 and 5-hp. motor through a combination of worm, wormwheel, chain drive, pawl and ratchet. The effective stroke of the pawl is controlled by a lever on the boiler-room floor.

The ashes discharged from the clinker grinders fall directly into an inclined trough, where they are swept along by a stream of water to a pit on the river front. For a more complete description of the hydraulic ash-removal system see page 680 of the May 2 issue of *Power*.

Returning to the stoker proper, each retort fires 17 lb. of coal per stroke, making a total of 476 lb. per stroke for the two 14-retort stokers in one boiler. The speed varies from one-quarter to one stroke per minute, giving a firing rate ranging from 3½ tons (2,000 lb.) to 14 tons per hour per boiler

The stoker-driving mechanism consists of four main

drive shafts for each group of 6 boilers, one shaft running along each side of each row of three boilers and driving the stokers on that side. The drive shafts are under the boiler-room floor and are driven (through Morse silent-chain drives) by variable-speed transmissions. Power is transmitted from the mainshaft to the stoker speed shafts by means of roller-chain drives,

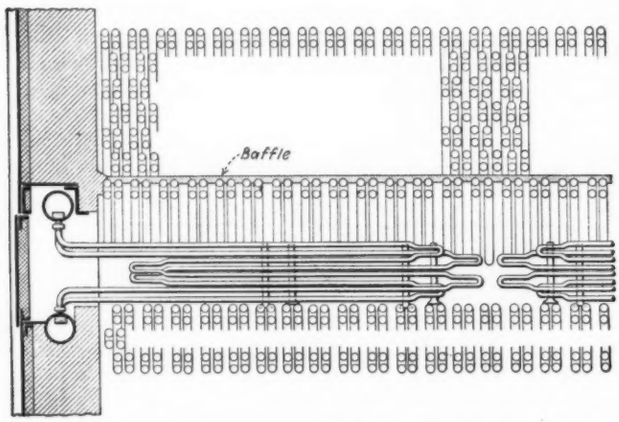


FIG. 5. SECTION THROUGH BOILER TUBES SHOWING ONE SET OF SUPERHEATER ELEMENTS

and from this point to the stoker crankshafts through double-worm reduction gears.

Each drive consists of a constant-speed 25-hp. 220-volt motor, chain-connected to a Lewellen variable-speed transmission (speed ratio 1:1 to 1:4). Two such drives are provided for each mainshaft, one being a spare. By means of clutches each shaft may be divided into three sections, one per boiler. Any one of these sections may be cut out while the other two are operating. Part of the stoker-driving mechanism is shown on the right-hand boiler of Fig. 3 and the remainder on the left-hand boiler.

The headpiece of this article shows parts of the driving system as follows: *A*, variable-speed transmission; *B*, chain drive from variable-speed transmission to main shaft under floor; *C*, four chain-drives to one stoker; and *D*, double worm reducing gears. The speeds at various points are as follows, in revolutions per minute: Motor shaft, 690; driven shaft of variable-speed transmission, 245; driving shaft of variable-speed transmission, 122 to 488; mainshaft, 60 to 240; first wormshaft, 89 to 356; ram crankshaft, 0.25 to 1.

The boilers are equipped with Elseco Superheaters, having a total surface of 2,135 sq. ft. The location of the superheaters between the sixth and seventh rows of tubes, as shown in Figs. 3 and 5, has already been mentioned. It will be noticed that the superheater tubes are at right angles to the boiler tubes.

As may be seen from Fig. 5, the superheater consists of two sets of elements, connected to two pairs of headers, one on each side of the boiler. The headers are located in the side walls with the result that the unit joints are placed outside the path of the gases. These joints are formed by forging the unit ends and grinding them to a ball shape to fit into 45-deg. seats in the headers. No gaskets are used. The units are held to the headers by forged steel clamps and heat-treated, alloy-steel studs. Each unit consists of two continuous loops of 1¼-in.-diameter, No. 9 (B. W. G.), seamless steel tubing, provided with return bends made from the unit pipe by the drop-forging process.

In the design and location of the superheater the following aims were kept in mind: (1) A superheater to give 200 deg. superheat at low first cost; (2) a safe gas-temperature zone for the superheater units; (3) minimum fluctuation in steam temperature at different boiler ratings; (4) high steam velocities with minimum pressure drop; (5) equal distribution of steam through all units at minimum as well as at maximum rating; (6) breaking up of possible slugs of water; (7) minimum number of steam-tight joints; and (8) elimination of baffle joints between superheater and boiler, to prevent bypassing the gases.

The units are exposed to the combined action of the radiant heat from the fire and convection heat from the gases. The steam velocity maintained, amounting to about 4,000 ft. per min. at 200 per cent of boiler rating, automatically keeps the tubes clean on the inside, while the triple reversal of flow by the forged bends breaks up any slugs of water.

Balanced draft is automatically maintained by special regulators which will be described later in this article. The plan of the forced-draft ducts for the two groups of boilers now installed is shown in Fig. 6. These ducts are located along the ceiling of the boiler-room basement. The layout consists of a main duct running along the west wall of the basement, with two branch ducts for each row of three boilers. These have four outlets per stoker.

Four Sturtevant fans, one of which is a spare, are provided on the main duct for each group of six boilers, and dampers, normally closed, are located in the main duct between the groups. These fans have a capacity of 120,000 cu. ft. of air per min. (each) at 7 in. pressure. They are direct-connected to 202-hp. 2,200-volt brush-shifting motors controlled by push buttons located in the heat-balance control gallery of the operating room.

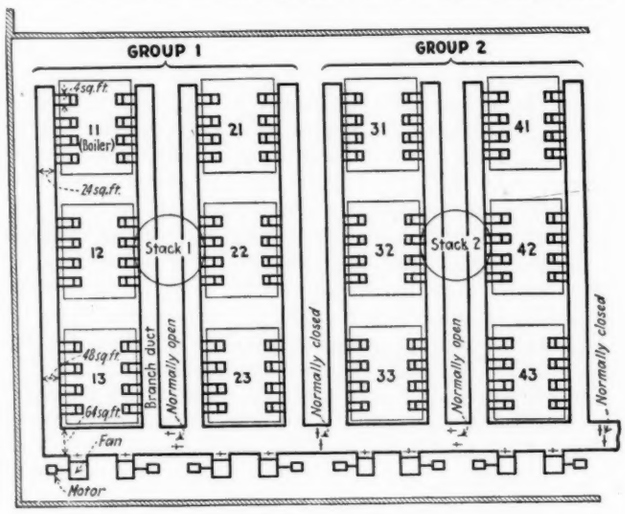


FIG. 6. DIAGRAM OF FORCED-DRAFT DUCTS

The forced-draft fans are in a separate room in the basement and take air through inlets from the air gap between the buildings. This prevents a partial vacuum in the building due to the fans, which would draw cold air into the building in winter.

The cinder catchers, induced-draft fans, breeching and stack for one group of six boilers are shown in Figs. 3 and 7. The 113-sq.ft. uptake from each boiler discharges into an individual cinder catcher, where a baffle produces a sudden reversal of flow at a velocity of about

3,000 ft. per min., with the result that the cinders are thrown down into a tank of water.

The gases from each boiler then pass to the group breeching by way of an individual, Sturtevant, induced-draft fan of 140,000-cu.ft.-per min. capacity at 6-in. pressure. This is direct-connected to a 198-hp. 2,200-volt remote-controlled brush-shifting motor. Fig. 8

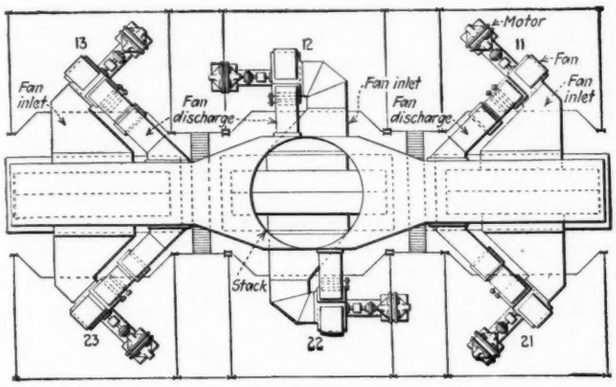


FIG. 7. INDUCED-DRAFT EQUIPMENT FOR ONE GROUP OF SIX BOILERS

shows one of these fans with its motor and electrical control apparatus. The induced-draft motors are started by hand, but are thereafter automatically regulated by the balanced-draft control. Provision is made to bypass the flue gases around the induced-draft fans inasmuch as these fans are needed only at peak loads.

The group stack, which is supported on the upper steelwork of the boiler room, has an internal diameter of 21 ft. and rises 258 ft. above the boiler-room floor. It is made of steel and lined with 4 in. of hard-burned red brick, coated inside with one inch of special cement.

The draft control (made by the Engineer Co.) at the Hell Gate Station is somewhat novel in that the induced-draft fans are included in the automatic regulation. Balanced draft is required in order to secure good combustion and to maintain a slight suction over the fire as a safety precaution.

The furnace-pressure regulator consists of a chamber divided by a plate diaphragm pivoted at one end. One side of this chamber is connected to the furnace so that the diaphragm moves in or out appreciably with slight changes in furnace pressure. This motion operates a pilot valve, which in turn controls the flow of water to a pair of small hydraulic cylinders, whose pistons are connected by counterweighted chains to dampers in the forced-draft ducts and in the flue respectively. To avoid momentary excesses of furnace pressure, the operating cylinders are so connected that the flue damper opens before the forced-draft damper and closes after it.

When, at the start of a peak-load period, it is necessary to put the induced-draft fan into operation, it must be started by hand. Thereafter its speed is varied automatically through a brush-shifting control operated by a special switch operated by the chain that controls the flue damper.

The forced-draft fans are controlled manually. Hand-operated forced-draft dampers are also provided in addition to those controlled automatically.

Reference has already been made to Fig. 9, showing the steam piping layout for one group. Because of the group system it is possible to use a remarkably simple arrangement of piping. There is one header, starting 12 in. and finishing 18 in., for each row of three boilers. Steam from each boiler passes to the header through two 10-in. connections. Starting at the boiler, one of these 10-in. connections contains (1) a stop and check valve, (2) a flow-meter orifice and (3) a motor-operated gate valve.

These motor-operated gate valves can be opened or closed by controllers located at the valves. An emergency closing controller which simultaneously closes both gate valves of a boiler, is located on the boiler-room floor. All other motor-operated valves can be opened or closed by controls at the valves. In addition they can be closed by controllers on the boiler-room floor. The electrical valve operating and control equipment was furnished by Payne Dean Ltd.

A single 18-in. main running the length of the boiler-room along the east wall is connected to all the headers, with three motor-operated valves at each connection. Although each row of boilers normally supplies the corresponding turbine, these valves make it possible to supply either main turbine of a group from either row of boilers. The house turbine and steam-driven auxiliaries in the operating room and basement are supplied by lines from the connecting main. The valves between groups are normally closed so that the groups are entirely independent. The steam velocities, when the group is developing 75,000 kw. with five boilers in service, range from 14,000 to 18,000 ft. per min. in the 18-in. mains supplying the turbines, and are about 7,000 ft. per min. in the boiler connections.

The steam piping is supported on pipe hangers, some of which are provided with springs to take care of expansion. All piping, both steam and feed-water, over

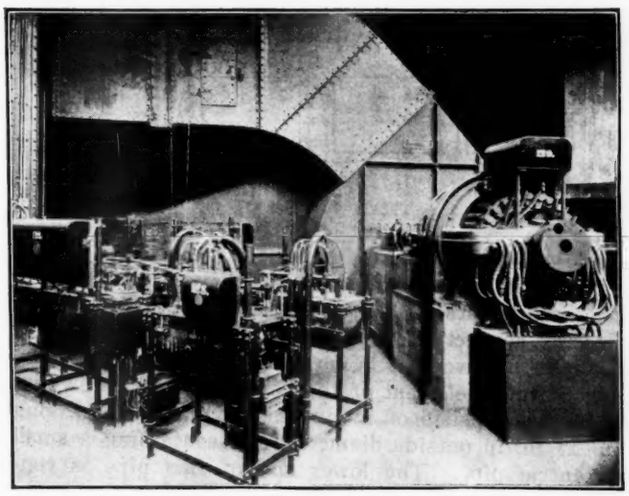


FIG. 8. INDUCED-DRAFT FAN, MOTOR AND ELECTRICAL CONTROL

5-in. is of wrought steel with Vanstone joints. Piping 5-in. and under is of wrought iron. Fittings are of cast steel. In this connection it should be noted that the average steam temperature is around 606 deg.

No traps are used in the boiler room. The high-pressure drips are carried to four double-acting simplex Davidson pumps which return them to the boilers.

The boiler settings, as already stated, are insulated with 4 in. of Sil-O-Cel brick. Boiler headers and drums are covered with 3½ in. of Sil-O-Cel brick finished off

with ½ in. of 85 per cent magnesia cement. All other heat insulation is 85 per cent magnesia. The high-pressure steam lines are covered with two layers, each 1½ in. thick, separated by asbestos millboard. The low-pressure and exhaust lines are insulated with a single layer one inch thick, while a 2-in.-thick covering (single-layer) is used on the feed-water lines.

Fig. 10 shows the boiler-feed piping of the first group from the feed pumps on. The specifications for feed piping and fittings are the same as for the steam piping. The feed temperature is held constant around 210 deg. There are three 6-in. 4-stage centrifugal, 1,000-gal.-per-min. feed pumps per group. Two of these are direct-connected to 375-hp. 2,200-volt motors, while the other is a stand-by unit direct-connected to a 320-hp. steam turbine. Any or all of these pumps may supply feed water to either row of boilers by means of 10-in. mains which reduce to 8-in. after passing the first two boilers of each row. By means of an 8-in. cross-connection at the ends the feed mains for one group form a continuous loop. The connection to each boiler is by means of a 5-in. pipe containing a gate valve and a globe check valve. This branches to two 4-in. connections, each of which contains a drumhead stop-and-check valve and an "S.C." boiler-feed regulator. A flow meter in the 10-in. main measures the water supplied to the three boilers. As in the case of the steam piping, the only connection from one group to the next is by means of a valve that is normally closed.

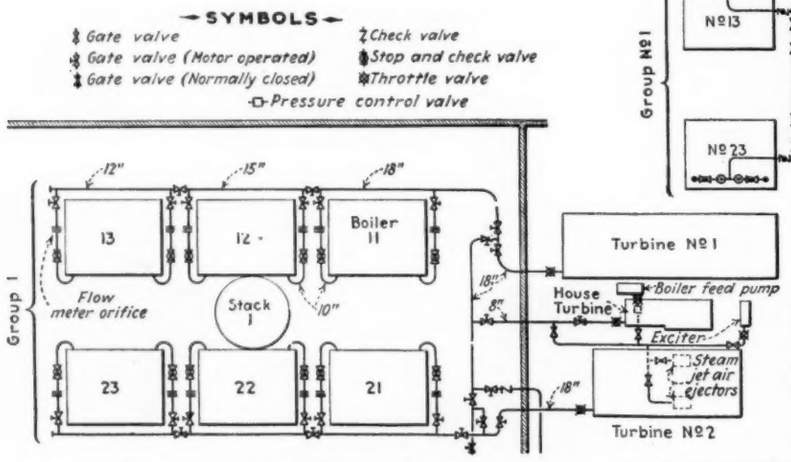


FIG. 9. STEAM PIPING OF GROUP 1

The control element of the boiler-feed regulator just mentioned consists of an inclined cylinder 10 in. long and 1½ in. in outside diameter, and containing a small concentric pipe. The lower end of this pipe is connected to the boiler drum at a point below the water line and contains a cooling pocket in the connection. The upper end is connected to the steam space of the drum. The space in the generator surrounding the small pipe is filled with water.

With the water at the highest level in the drum, the small pipe in the generator is entirely filled with water. As the water level in the drum drops, steam is admitted to the upper end of the pipe, causing the upper surface of the water surrounding the tube in the generator to flash into steam. The induced pressure, carried through a capillary connecting tube to the controlling-valve diaphragm, opens the valve admitting water to the boiler. When the water rises the operation is reversed.

The boilers are equipped with Diamond soot blowers, 24 elements per boiler. Inclined gage glasses are used so that the water level in the boilers may be seen from the floor without difficulty.

An article in the May 16 issue of *Power* will describe the system of heat balance. The control board for this purpose is located in a gallery above the turbine-room floor and carries, along with other instruments and apparatus, a number of instruments for indicating or recording various boiler-room quantities. Among these are two pressure gages indicating the steam pressures in the main headers, and two recording gages, each of which measures, for one group, the main-header steam pressure and the water pressure at the feed pumps. This control board also carries four 3-point indicating draft gages, each of which gives the furnace pressures for the three boilers of one row. Four recording air-pressure gages measure the forced draft pressures in the branch ducts leading to the four rows of boilers. In the chief's office there are two gages which record the steam pressures in the main headers.

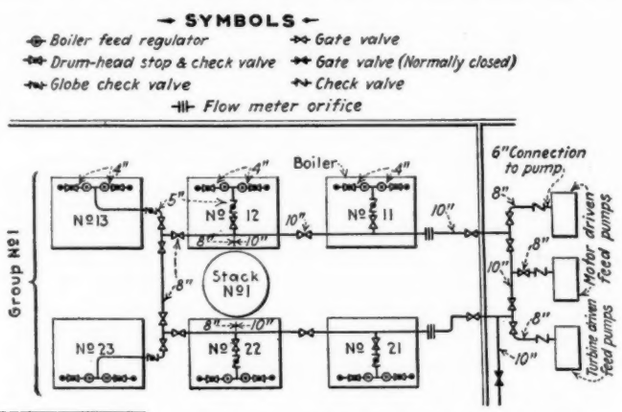


FIG. 10. FEED-WATER PIPING OF GROUP 1

The boiler room itself contains, in addition to various steam gages, instruments for measuring steam flow, feed water, air flow, flue temperature, firebox draft, forced-draft air pressure and blow-down. Each boiler is equipped with a boiler meter which records steam flow, air flow and average flue temperature, and indicates the draft in the firebox. In addition to an individual steam-pressure gage on each boiler, there are two 18-in. pilot gages placed at the ends of the group-center firing aisles. There are eight dead-beat indicating air-pressure gages, one for each branch duct supplying air to one side of a row of three boilers.

The combined blowdown for the entire present installation of twelve boilers is measured by an integrating V-notch blowdown meter. The table of equipment at the end of the general article describing this station in the May 2 issue of *Power*, gives a list of the various instruments, with the names of the companies that furnished them.

The material for these three articles on the Hell Gate Station was obtained through the co-operation of Frank W. Smith, vice-president and general manager of the United Electric Light and Power Co., and Thomas E. Murray, Inc., engineers, who—working in conjunction with an advisory committee of engineers from the various central stations of Greater New York—designed this plant and supervised its erection.

Selection of Electric Motors

By GORDON FOX
Electrical Engineer, Freyn Brassert & Co., Chicago, Ill.

FACTORS affecting motor applications, such as voltage, speed, efficiency, power factor, basis of rating and local conditions, are discussed.

AS THE system to which motors are to be connected is usually already in existence, it determines largely such questions as voltage and frequency. In the development of new plants there may be a choice. With reference to frequency it may be said that, even though power is independently generated, the establishment and prevailing utility frequency in the district should be adopted. The future, if not the present, may give rise to such needs as breakdown service, extensions or parallel operation. The way should be left open by

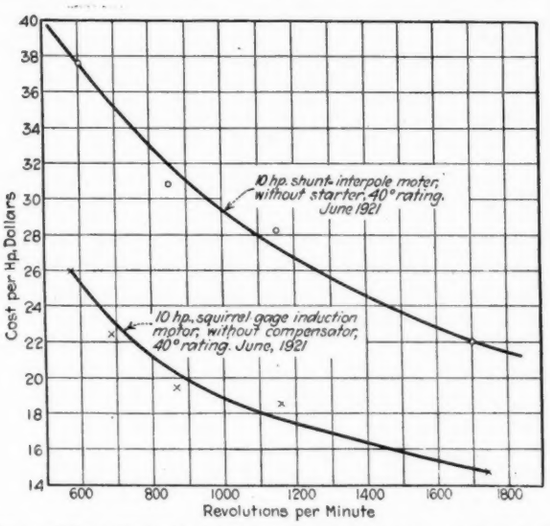

Cost per Hp. Dollars
Revolutions per Minute
10 hp. shunt interpole motor, without starter, 40° rating. June 1921
10 hp. squirrel gage induction motor, without compensator, 40° rating. June, 1921

FIG. 1. RELATIVE COSTS OF ALTERNATING- AND DIRECT-CURRENT MOTORS AT VARIOUS SPEEDS

adoption of the common frequency. In general 60 cycles is to be preferred. Induction motors for this frequency afford a wide selection of speeds. They are smaller, lighter and cheaper than 25-cycle motors and equal or superior in performance, excepting in the case of slow-speed motors. The latter have low power factor, but the 60-cycle motor is particularly poor in this respect.

The choice of voltage for direct-current systems rests among 115, 230 and 550 volts. The lowest voltage is satisfactory in operating features, but involves heavy copper for distribution without excess voltage drop. The 550-volt motor tends to be a little "touchy." Its commutation is more likely to be imperfect, and it is more dangerous. Small motors, shunt fields, control magnets, brake coils, all involve the use of fine wire, which is consequently subject to breakage. On systems where plugging is practiced, pressures of 1,000 volts or more may arise, owing to the addition of motor voltage to system voltage.

Usually, 230 volts prevails for direct-current motors and is more nearly standard. Motors and control for this voltage are highly developed, lower in price and quicker in delivery than for other voltages. For these reasons it may be recommended that preference be given to 230 volts for industrial service, comprising the disadvantages of both lower- and higher-voltage systems. The principal advantage of 550 volts is the economy in distribution. Industrial distribution distances are short, and the advent of the automatic substation may make them shorter. The greater reliability and lower cost of 230-volt apparatus fully warrants the slight additional distribution expense.

Alternating-current motors are standard for 110, 220, 440, 550, 2,200 and 6,600 volts. Single-phase motors are usually wound for 110 or 220 volts for connection to lighting-service wires. Industrial systems are usually 220 or 440 volts. The lower voltage is preferred by some on the score of safety. Where motors of small size alone are involved and where distances are short, the 220-volt system is probably preferable. Where larger motors, above 25 hp., are involved and where transmission distances are considerable, the use of 440 volts offers advantages in distribution economy with equal reliability. Motors for 110, 220 and 440 volts all have the same insulation and may often be changed from one voltage to another by changing the end connections. Motors for 550, 2,200, and 6,600-volt service are more heavily insulated. For these voltages motors may be had in sizes as low as 25 hp., the small sizes being

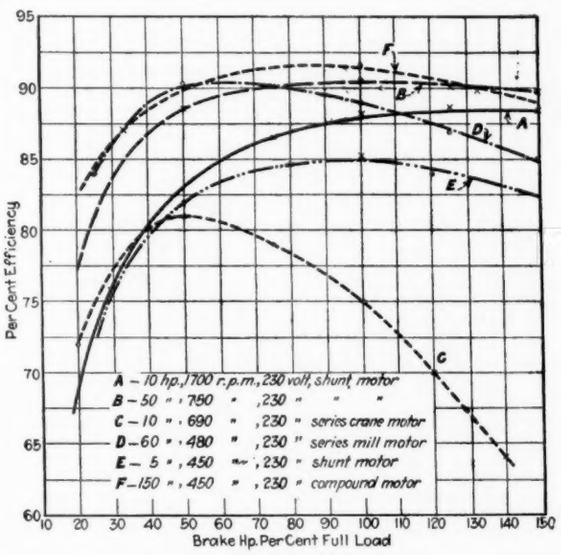

Per Cent Efficiency
Brake Hp. Per Cent Full Load
A – 10 hp., 1700 r.p.m., 230 volt, shunt motor
B – 50 " , 750 " , 230 " " "
C – 10 " , 690 " , 230 " series crane motor
D – 60 " , 480 " , 230 " series mill motor
E – 5 " , 450 " , 230 " shunt motor
F – 150 " , 450 " , 230 " compound motor

FIG. 2. EFFICIENCY CURVES OF TYPICAL DIRECT-CURRENT MOTORS

used for power-house and substation auxiliaries. For general industrial service the higher voltage is not to be recommended for motors below 100 hp. High-voltage motors should be used only when not unduly exposed and when both motor and control may be properly protected. The use of the lower voltages may be dictated in some cases to gain the advantages of greater simplicity, lower cost and better performance of the control.

There may or may not be a choice in the speed rating

of a motor for driving a given machine. Where direct connection is feasible, it is usually desirable. The motor speed is then dictated by the machine requirements. With gear, chain or belt drive there may be a choice in motor speeds. Primarily, the speed selected must be such as to give good mechanical-drive conditions. Within limitations it is usually desirable to utilize as high a motor speed as feasible, as the cost of the motor is thereby diminished. The horsepower rating of a motor frame is closely proportional to the speed, but as the elements of cost differ in frames of different sizes, the cost of motors is not in exact proportion to the speed. The curves in Fig. 1 show the variation in cost of standard 10-hp. motors, shunt-wound and squirrel-cage induction types, over a range of speeds. This merely indicates the general condition. In the case of direct-current motors it is suggested that 1,200 r.p.m. be maximum for small motors and 900 r.p.m. for larger motors, as the high-speed motors are more liable to commutation difficulties.

Importance of Motor Efficiency

The question of motor efficiency is of some importance. A reliable and effective drive is essential. Efficiency is secondary but not negligible. A motor that has two or three points advantage in efficiency may save a worthwhile margin in power consumption. Load factor or utilization factor plays a determining part. If a motor is seldom used and but lightly loaded, a given percentage of economy leads to a lesser saving than in the case of a motor in continuous operation and well loaded. The question of efficiency is particularly pertinent as applied to the larger motors for such equipments as fans or compressors. The margin in first cost justified by increased efficiency may be approximately computed in any case. The influence of speed on efficiency should be mentioned.

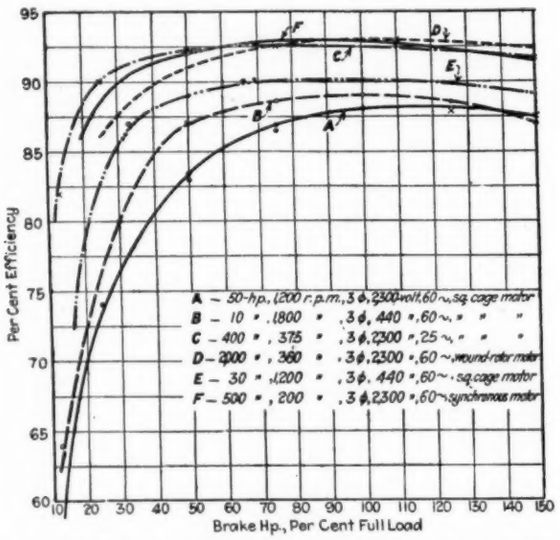

Per Cent Efficiency
Brake Hp., Per Cent Full Load
A — 50-hp., 1200 r.p.m., 3 ϕ, 2300-volt, 60 ~, sq. cage motor
B — 10 " , 1800 " , 3 ϕ, 440 " , 60 ~, " " "
C — 400 " , 375 " , 3 ϕ, 2300 " , 25 ~, " " "
D — 3000 " , 360 " , 3 ϕ, 2300 " , 60 ~, wound-rotor motor
E — 30 " , 1200 " , 3 ϕ, 440 " , 60 ~, sq. cage motor
F — 500 " , 200 " , 3 ϕ, 2300 " , 60 ~, synchronous motor

FIG. 3. EFFICIENCY CURVES OF TYPICAL ALTERNATING-CURRENT MOTORS

In general, the higher-speed motors are more efficient, particularly in the case of alternating-current machines. Tables I and II show efficiencies of 10-hp. motors, shunt-wound and squirrel-cage types, at various speeds. The efficiency of a motor is usually highest at about full load. There is therefore a measure of advantage in operating the motor under sufficient load to realize good economy. The variation of efficiency with load is illustrated in Figs. 2 and 3.

In the case of motors that are subject to frequent starting and stopping, as in traction service or steel-mill auxiliary applications, over-all efficiency should be considered rather than motor efficiency. The resistance losses are usually of greater magnitude than the motor losses. Resistance losses can be minimized through the use of the proper gear ratio and most advantageous control. As the losses with this type of drive may be relatively high, the question of efficiency takes an aspect of increased importance.

Power factor is receiving ever greater consideration. Poor power factor penalizes both the capacity and the

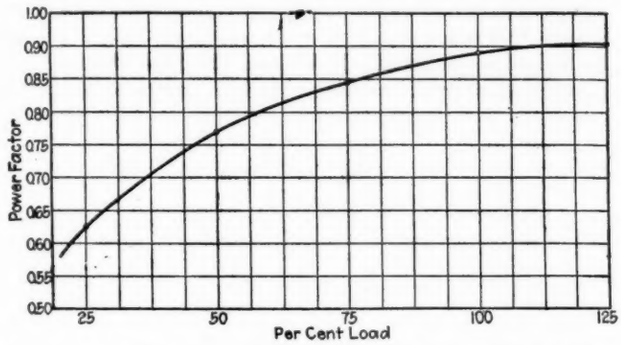


FIG. 4. POWER FACTOR OF SQUIRREL-CAGE 10-HP., THREE-PHASE, 60-CYCLE, 440-VOLT INDUCTION MOTOR

efficiency of generating, conversion and distribution equipment. Because of its ability to operate with high or leading power factor, the synchronous motor is becoming more popular and its performance is being steadily improved. It is suggested that all continuously running drives of the larger size should be carefully considered as possible applications for the synchronous motor.

The power factor of the induction motor is highest under load as the magnetizing current remains approxi-

TABLE I. EFFICIENCY OF TYPICAL SHUNT INTERPOLE DIRECT-CURRENT MOTORS

Ten horsepower, 230 volts, general service type

Speed	Per cent Efficiency One-half Load	Per cent Efficiency Full Load	Speed	Per cent Efficiency One-half Load	Per cent Efficiency Full Load
1,700	80.5	86	850	85.5	87
1,150	83.0	86.5	600	82.0	85

TABLE II. EFFICIENCY AND POWER FACTOR OF TYPICAL SQUIRREL-CAGE INDUCTION MOTORS

Ten horsepower, 60 cycles, 440 volts, 40 deg. rating, general-service type.

Speed	Efficiency		Power Factor	
	One-half Load	Full Load	One-half Load	Full Load
3,450	88	90	87	93
1,750	84.5	88	80	90
1,160	85.5	88	77	88.5
870	85	87.5	67.5	84
690	85.5	86	60	80
575	85.5	86	58	78

mately constant while the load current increases. Fig. 4 shows the variation of power factor with load in a 60-cycle motor. It is evidently desirable that the operation of induction motors at light loads is to be avoided, where possible, because of the influence on power factor. The power factor of low-speed motors is lower than that of high-speed motors because of the higher magnetizing current required. Table II shows the power factor at various loads, of a line of 10-hp. squirrel-cage 60-cycle induction motors. It will be seen that the power factor at low speeds is relatively poor.

Current taken in starting a squirrel-cage induction motor or a self-starting synchronous motor is at a power factor of about 30 to 40 per cent. This is due to mag-

netic leakage and low rotor power factor with high rotor frequency. The starting power factor of a wound-rotor induction motor or a high-resistance squirrel-cage motor is higher, owing to a greater resistance component.

Pertinent to the present double basis in use for rating general-utility motors, a few words may be in order. The so-called 40-deg. rating is a "normal" rating. A motor so rated will carry its full load continuously and not to exceed 40 deg. C. rise and will carry 125 per cent load for two hours and not to exceed 55 deg. rise. In applying a motor of this type, the normal load will be suited to the rating selected, and the occasional overload incident to many drives will be cared for by the inherent overload capacity. The so-called 50-deg. motor is maximum rated and will carry overloads of short duration only and then only if the heavy-load periods are offset by light-load periods closely preceding.

Some drives are not liable to overloading. They permit of close motoring and the 50-deg. motor is well adapted. Where overloads are at all probable, the 40-deg. motor is to be preferred or the 50-deg. motor rating should be discounted. The 40-deg. rating is about 85 per cent of the 50-deg. rating of the same frame. In general it may be said that the saving in maintenance and prevention of delays usually warrants a conservative practice in the selection of motor capacity. The fact may well be borne in mind that a large, heavy motor has considerable capacity for heat storage and is consequently more capable to handle overloads of short duration than a small, light-weight machine.

Effect on the Supply System

In selecting a motor, particularly one of large size, the effect upon the supply system must be considered. This refers particularly to alternating-current motors wherein the starting current is the principal disturbing element. Induction motors of large size with respect to the generating capacity on the system should be preferably of the wound-rotor type. If a squirrel-cage or self-starting synchronous motor is applied, the lowest effective starting voltage should be used. The National Electric Light Association has formulated a table of maximum allowable starting currents recommended for motors permitted on the systems of its member companies. This is given in Table III as indicating desirable practice.

TABLE III. MAXIMUM PERMISSIBLE CURRENT VALUES FOR, THREE-PHASE, 60-CYCLE MOTORS AT 440 VOLTS, N.E.L.A. STANDARDS

Currents at other voltages proportionate

Amperes per Phase per Horsepower

	I. Normal Starting	II. Locked Rotor
Two to five horsepower	6.5	8.7
Five to thirty horsepower	4.5	6.0
Above thirty horsepower	3.0	4.0

Values in column I are ¾ of those in column II and are the currents indicated by a well-damped ammeter.

How Local Considerations May Influence Motor Selection

Some features of motor selection may be influenced by local considerations. For instance, explosion danger may dictate the elimination of collector devices and the submergence of control in oil. Moisture, heat, chemicals or dirt may dictate the use of special insulations or varnishes or total enclosure with special ventilation provisions. Local regulations such as insurance or mining laws may dictate the maximum voltage, etc. The type of workmen that will use and maintain the equipment must be considered. Where a brake, acting on the armature shaft, is called upon for frequent retarding, it may tend to transmit heat to the motor. The extent and type of overload protection desirable is a question often arising in connection with the control. The requirement of safety devices is sometimes a factor. Many similar special conditions may arise in individual cases.

Last but not least, should be mentioned the desirability of duplicating equipment so far as feasible in any given plant. The use of a minimum number of frames and ratings renders more easy the interchange of motors, facilitates repairs and replacements and greatly reduces the necessary expenditure and increases the value of spare apparatus and parts. The duplication of apparatus is too often neglected to the handicap of both production and maintenance.

Fuel Oil for Diesel Engines

This specification covers the grade of oil used by the United States Government and its agencies as a fuel for Diesel engines.

Fuel oil shall be a hydrocarbon oil, free from grit, acid and fibrous or other foreign matters likely to clog or injure the burners or valves. If required, it shall be strained by being drawn through filters of wire gauze of 16 meshes to the inch. The clearance through the strainer shall be at least twice the area of the suction pipe, and the strainers shall be in duplicate.

Flash Point—The flash point shall not be lower than 150 deg. F. (Pensky-Martens closed tester).

Water and Sediment—Water and sediment combined shall not amount to more than 0.1 per cent.

Carbon Residue—The carbon residue shall not exceed 0.5 per cent.

Precipitation Test—When 5 c.c. of the oil is mixed with 95 c.c. of petroleum ether and allowed to stand 24 hours, it shall not show a precipitate or sediment of more than 0.25 c.c. (5 per cent by volume of the original oil).

All tests shall be made according to the methods for testing fuel oils adopted by the Committee on Standardization of Petroleum Specifications.

Whether or not Henry Ford's offer for the completion of the Muscle Shoals project is accepted by the Government, he has done a big thing for the South, according to the *Manufacturers' Record* (published in Baltimore), in centering the attention of the public and of Congress upon the great possibilities of the Tennessee River for transportation and for hydro-electric development. Mr. Ford's offer, says the *Record*, has given the South "a greater advertisement than all the railroads and all the water-power companies in this section combined have ever given it." It is stated further that other water-power development projects have been brought to Mr. Ford's attention, and that he may take them up and supply the necessary capital if the Government does not accept his Muscle Shoals offer.

In the average boiler plant 70 per cent of the operating cost of generating steam is for fuel. When investigation shows the possibility of increasing the boiler efficiency from 50 per cent to 60 per cent or from 60 per cent to 70 per cent, the tendency is to consider it only as a 10 per cent increase in efficiency instead of an actual saving of 20 per cent or 16.6 per cent, respectively, of fuel.

Relieving the Back Pressure In Reversing Unaflow Engines

FOR rapid reversing of unaflow steam engines, such as is necessary in blooming mills, locomotives, automobile, trucks, tractors and marine engines, some kind of relief valve is necessary to avoid excessive compression in a cylinder full of high-pressure steam.

Such relief valves need not be large unless extremely rapid reversing is required. They should be, in fact, no more than small exhaust valves, near the inlet end of each cylinder. With poppet valves for the admission of steam these exhaust valves should likewise be of the poppet type. They are also thrown into operation by the valve gear when the admission valves are working with a long cutoff.

A poppet-valve design with small, automatically operated relief valves is shown in Fig. 2. The relief valves *AA* at the bottom of the cylinder are small and can be thrown open by forcing a wedge *B* between the ends of the valve stems. This wedge is loosely hung, so that if it is not forced in too far, one valve may close and the other one remain open. It has been found that admission of steam into one end of the cylinder causes a rush through the open relief valve, which will instantly close and by striking the wedge will open the opposite one, thus providing relief of compression with but an insignificant loss of live steam.

The use of such automatic relief valve was first tried on pairs of single-acting cylinders with cranks, at 180 deg. These were small high-pressure cylinders designed for automotive work. On large cylinders such automatic relief valves would probably have to be provided with some kind of dashpots.

A piston-valve arrangement with a modified Joy valve gear for tractor work is shown in Fig. 1. The middle piston valve *A* is hollow and controls the primary steam-inlet ports. Steam flows to the valve chamber *C* through a pipe *B* from one end of the jackets, as indicated by the dash lines in the vertical cross-section.

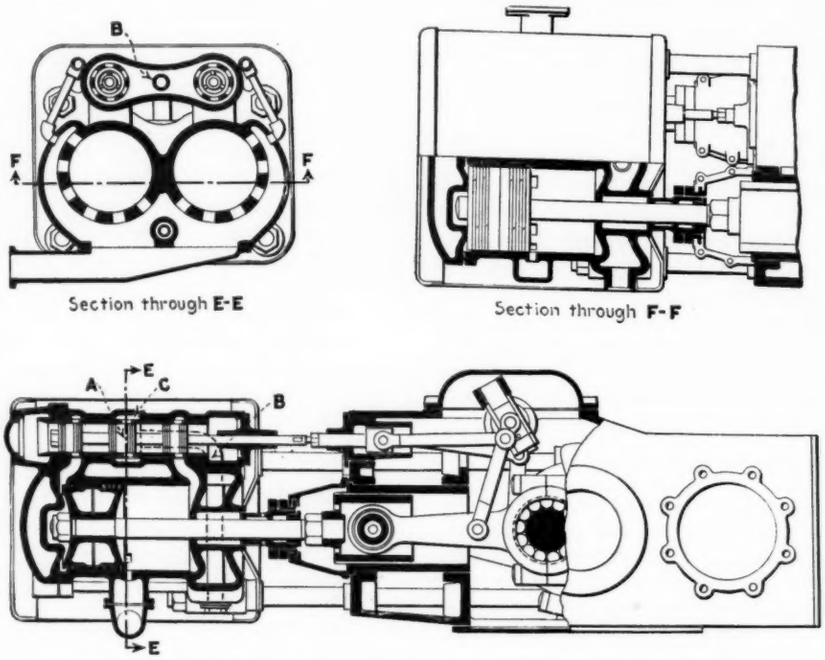


FIG. 1. REVERSING ENGINE USING DOUBLE PISTON VALVE

The lap between the steam ends of the center valve and the two outer piston valves is such that the end and the center valve admit the steam at about the same time, the steam from the center steam chamber passing through hollow valve stem. The outer valves are designed to be long enough to keep the inlet port covered entirely during the expansion and back pressure period except when the travel of the valve is long, as with the longer cutoffs. When these outer valves over-travel the inlet ports, they allow some of the steam to be exhausted from the ends of the valve casing through small pipes, connected with the exhaust belt, as shown in the end-view section. Compression is thereby varied just as it would be in a piston-valve locomotive.

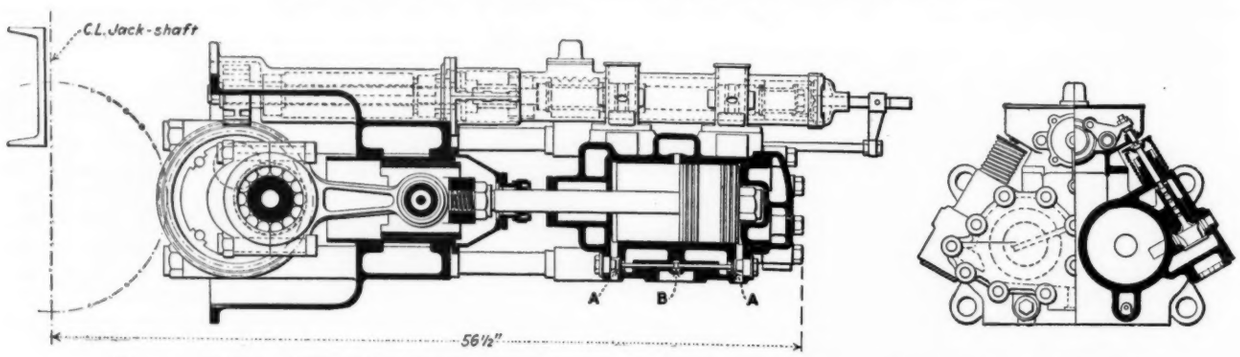


FIG. 2. SMALL AUXILIARY EXHAUST VALVES RELIEVE THE BACK PRESSURE ON REVERSAL

The use of exhaust valves violates the unaflow principle for a few starting strokes, but most of the steam with its moisture is exhausted through the cylinder

ports opened by the piston, and a relatively small quantity of steam returns past the inlet end of the cylinder, which should be left hot by jackets, which are all the more important for such service. Furthermore, engines of this type are run for so great a part of the time with short cutoffs, and even sometimes with no load at all, that the Stumpf Unaflow design is the most efficient that can be used.

Making Ammonia Compressors Safe

Accidents to ammonia compressors are by no means uncommon and are usually of more concern than a like breakage on a steam engine. In the majority of cases the accident happens to slow-speed machines, the trouble being confined to an initial breakage of one of the poppet valves leading up to the destruction of the cylinder head, piston or other expensive parts.

In an attempt to eliminate the danger of the poppet valve dropping into the cylinder when the valve stem breaks, a safety collar *A*, Fig. 1 is customarily employed. Unfortunately, this does not eliminate all the danger, for it is by no means infrequent that the stem breaks at *B* below the collar. The valve then drops into the cylinder. The piston at the end of the stroke strikes the valve disc. Something must give way, and it is likely to be the cylinder head, as in Fig. 2. This compressor was put out of commission with a broken cylinder head and bent rod by the breakage of a valve.

To offset this danger, a number of firms are replacing the poppet valves and cages by a light disc valve, as

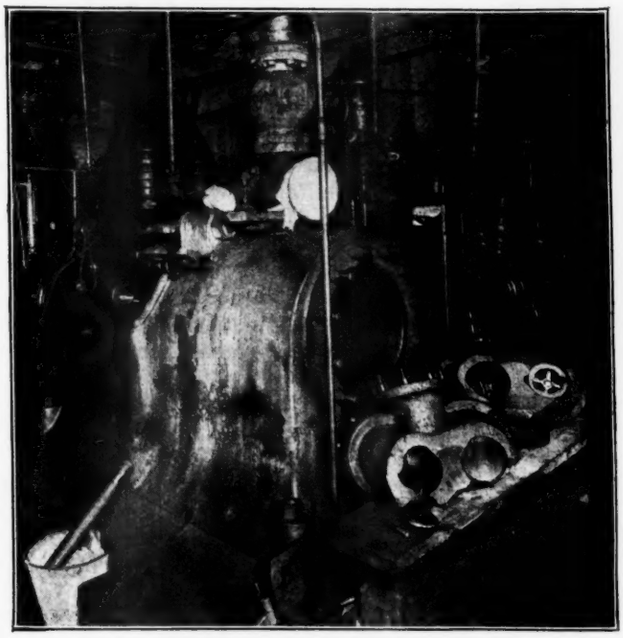


FIG. 2. COMPRESSOR DAMAGED BY FRACTURE OF VALVE STEM

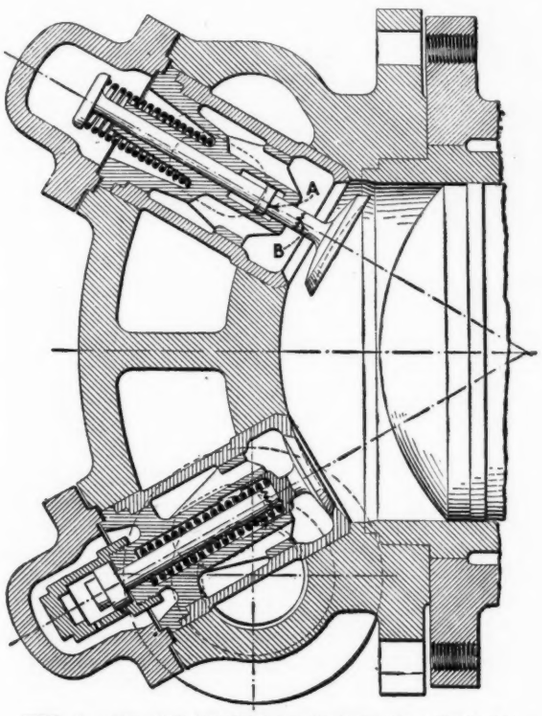


FIG. 1. HEAVY POPPET VALVES IN AMMONIA COMPRESSOR

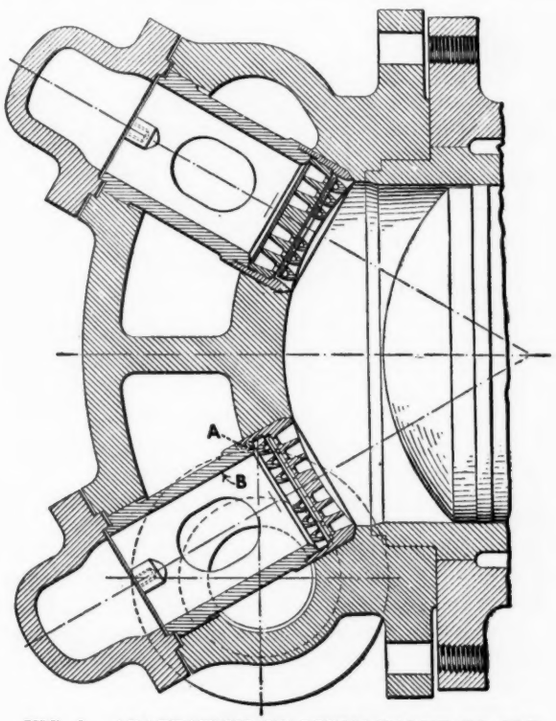


FIG. 3. ADAPTATION OF LIGHT VALVE TO OLD COMPRESSOR

shown in Fig. 3. The new valve *A* is made with an extension *B* which replaces the old valve cage and may be inserted with the minimum of shutdown.

A number of advantages result. The compressor is freed from any likelihood of breakage from valve trouble. If one of the ring or plate valves should break, it is so light in construction that the piston would merely crush it without further damage to the compressor. A second advantage lies in the increased speed at which the machine may be operated without valve hammering. By increased speed the capacity of the compressor is increased with little if any increase in the horsepower per ton of refrigeration.

In addition the valve resistance is decreased by the substitution of the light valve. In many machines the inertia of the heavy valves is such that a pressure drop of from 3 to 10 lb. is experienced by the gases in passing through the valve.

Advantages of Circulating Oiling Systems

By W. F. OSBORNE*

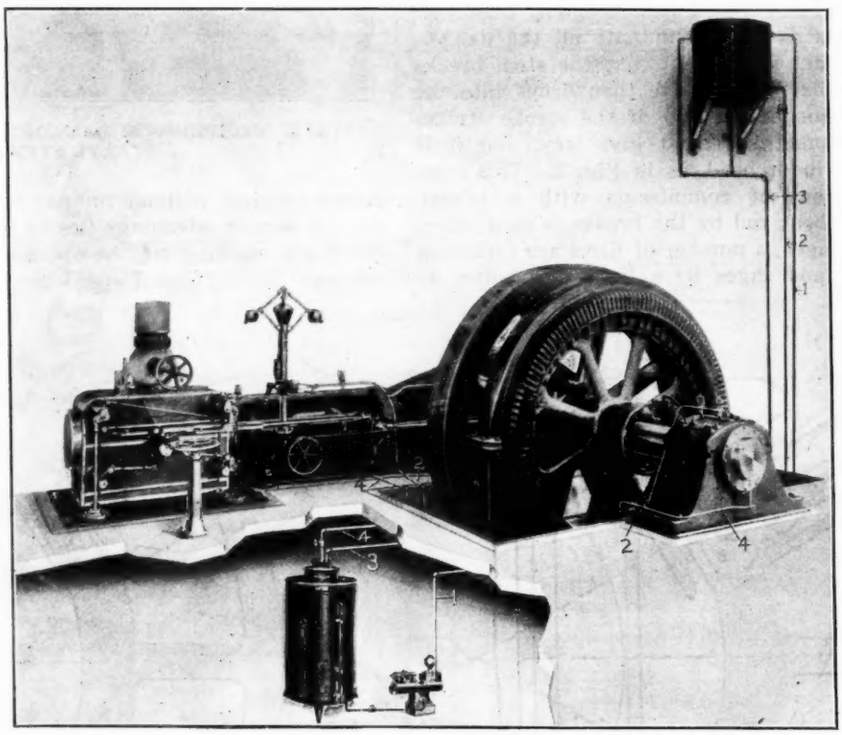
STRICTLY speaking, a circulatory oiling system, or circulating oiling system as it is commonly called, is any method of oiling in which the oil from the bearings is collected and automatically returned to the bearing for further use. There are many forms of the circulatory oiling system, but they all have the same four fundamental reasons for their use.

1. A large quantity of oil is supplied to the bearing, affording every opportunity for conditions of minimum friction losses.

2. The flood of oil serves to carry away the generated heat from the bearing surfaces and lowers the temperature.

3. The oil washes the bearing clean, removing any bits of worn metal or foreign matter that might settle on the bearing from the atmosphere.

4. The oil from the bearing is collected and used again, thereby reducing the oil consumption. The large amount of oil delivered to every bearing surface on the engine, turbine or other machine, prevents trouble from insufficient lubrication. All the oil that is necessary for the formation of a perfect lubricating film is available, and if mechanical conditions are suitable there is no reason why perfect lubrication should not be secured. Perfect lubrication results in minimum power losses and the elimination of all bearing wear.



CIRCULATING LUBRICATING OILING SYSTEM

The greater the quantity of oil passing through a bearing the larger will be the amount of heat carried away from the bearing surfaces. This, of course, is based on the assumption that the oil is not forced through the bearing so fast that there is any appreciable heat developed by the friction of the oil in its rapid journey through the bearing clearances. When more oil is furnished than can pass through the clearance, it will flow around the bearing shell if suitable passages are provided and help to cool the bearing. In other words, by acting as a carrier of heat from the bearing, the oil reduces the temperature below that at which the bearing would otherwise run.

The reduction of the temperature decreases the tendency of the oil to evaporate and decompose. In this way it increases the life of the oil, maintains it in good condition, lowers the consumption and holds the frictional losses at a minimum by preventing an excessive rise in the viscosity of the oil.

A flood of oil will also wash out of the bearing any bits of metal or foreign material that might settle onto an incompletely closed bearing. This constant washing out prevents wear of the metal and eliminates any tendency of the bearing to gum, which might be developed by an accumulation of foreign material.

All these advantages are dependent on the use of a considerable quantity of oil. If only fresh oil were used, the cost for new oil would be prohibitive. Indeed, it would be quite impossible to get enough barrels of oil and enough men around large turbines to supply the bearings with the quantity of oil they secure from the circulatory oiling system. Because of the large amount of oil furnished to the bearings, suitable means must be provided for collecting all the oil draining from them and returning it automatically to the bearings for further use. There are many methods of handling the oil for such systems, the principal ones being known as gravity, force-feed and splash, with many combinations of two or more of these.

The gravity system consists of a tank or reservoir to which the oil draining from the bearings may flow, a pump to take the oil out of the drain tank and a reservoir or gravity tank located above the level of the highest bearing, to which the oil is delivered by the pump. From this gravity tank the oil flows by gravity through suitable pipes to the various bearings requiring lubrication, as shown in the illustration.

Sometimes these oil pipes are connected directly to the bearings, in which case there will be a pressure on the bearing due to the height of the oil above the bearing. In most installations a sight-feed device is placed just above the bearing in order to regulate the amount of oil delivered. In such cases there is practically no pressure at all on the bearing, and the amount of oil

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passing through the bearing clearance will be practically the same as in the case of a ring oiler which is supplied with enough oil to keep the clearance space full.

The force-feed system differs from the gravity system in that the gravity tank is eliminated and the pump delivers the oil directly to the bearing. Here again are two types—one in which the oil is delivered to the bearing under pressure, and the other in which a sight feed is placed just above the bearing. The latter arrangement has the same effect of relieving all oil pressure from the bearings as explained in connection with the sight feed on the gravity system.

When the oil lines lead the oil to the bearing under pressure, whether from an overhead tank or from a pump, the flow of oil to the bearing will be positive, and if there is any obstruction in the line or bearing there is usually enough pressure available to force it out and maintain the supply. While the pressure from the gravity tank is constant, that from the pump can be regulated so that if the bearing seems to be running too hot, more oil can be forced through the clearance space by raising the pressure. This cannot be done when the sight feed is used, as even though the quantity of oil supplied to the bearing be increased, the amount actually flowing through the clearance will be unaffected for there will be no increased pressure to force it through.

Automatic Oiling Systems

When the force-feed system is applied to certain types of inclosed-crankcase engines, it is known as an automatic oiling system. The pump is located in the lowest part of the crankcase, and the oil is forced to all parts under pressure, returning to the crankcase for further use.

The splash system used principally for steam engines, air compressors and internal-combustion engines, requires a completely inclosed crankcase in which a quantity of the oil is placed. The end of the connecting rod dips into the oil and splashes it to all parts requiring lubrication. Sometimes the connecting-rod end is provided with a scoop or dipper to increase the quantity of oil splashed about. In some engines channels and grooves are arranged to collect the splashing oil and lead it to certain bearings, in this way providing more positive feed. The splash systems have the advantage that there are no mechanical parts to get out of order, and the entire system is self-contained.

A little thought will show that any of these systems will satisfactorily take care of the four fundamental reasons for using such a system. They vary in the degree of regulation that they permit. The splash system permits of no regulation whatever of the oil supply when the engine is running. The sight-feed system (in connection with either gravity or force feed) allows regulation of the amount fed to the bearing up to the capacity of the clearance space between bearing and shaft, while the pressure system (overhead tank or pump) allows a wide regulation through the variable pressures obtained.

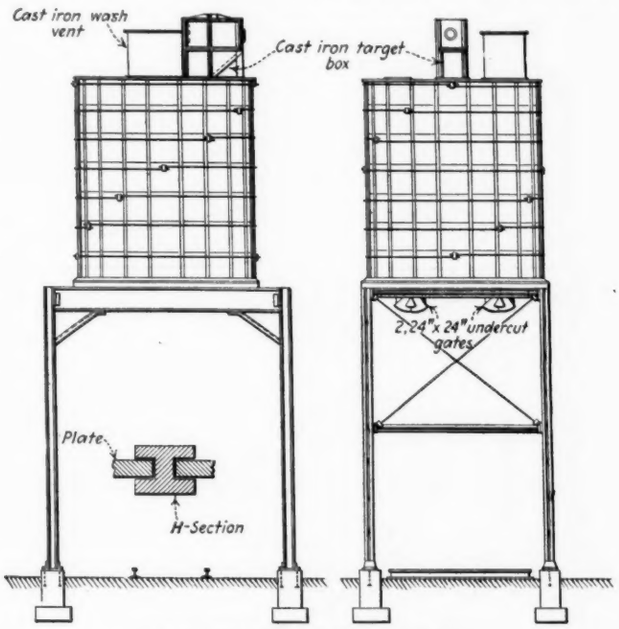
Since in all these systems the oil is used over and over again, we can realize that the efficiency of lubrication and reduction of wear is going to depend to a very large extent on the means provided to maintain the oil in its original good condition. The various factors that affect the quality of the oil in such a system will be explained in articles to follow on systems for steam engines, turbines and oil engines.

Sectional Cast-Iron Storage Tank for Coal and Ashes

The Conveyors Corporation of America, with headquarters at Chicago, has brought out a cylindrical cast-iron storage tank that is made up in sections, ½ in. thick and 2 ft. square. The vertical edges of these sections, or radius plates, are joined, as shown in the illustration, by pieces with an H-shaped cross-section, made in 2-ft. and 4-ft. lengths.

A rolled steel angle at the base, together with steel rods resting on lugs and running completely around the tank, holds the sections together and eliminates the necessity of structural support about the tank proper. All the inside joints are sealed with special cement to insure tightness and prevent leakage.

The top is of cast-iron, and when intended for the storage of ashes the tank is equipped as shown with



COAL OR ASH STORAGE TANK

It is made up of cast-iron radius plates joined by H-sections and held together by steel rods running around the outside.

the standard wash vent and target box used with the steam-jet ash conveyor. The tank rests on a reinforced-concrete slab 5 in. thick, supported on a structural steel base or tower, which is built up of standard structural shapes to a height conforming with local conditions, with sufficient clearance for wagons, trucks or railroad cars, as the case may be. The tank has a flat bottom, but to permit maximum withdrawal, is equipped with two 24 x 24-in. undercut gates.

Sixteen standard sizes are supplied, the clearances varying from 10 to 22 ft., and sizes ranging from 8 ft. diameter and 12 ft. height, to 16 ft. diameter and 22 ft. height. The capacities of these different-sized tanks, figured on a basis of 40 cu.ft. per ton, range from 15 to 110.5 tons. The weights range from 10,840 to 41,920 lb.

A ferryboat boiler exploded at Port Huron, Mich., on March 27, with a detonation that rocked the business part of the city and hurtled through the air for three hundred feet. As usual, the daily press reports ascribe the cause to low water. When a boiler explodes as demonstratively as this did, it is certain that there was plenty of water with plenty of heat stored in it.

Will Compounding of Internal Combustion Engines Pay?

By L. H. MORRISON

THE advantage of compounding in steam engines has been long recognized by engineers. Realizing the success gained in this field, there exists a strong feeling that equal success would attend the adoption of the compound principle in internal-combustion engine design.

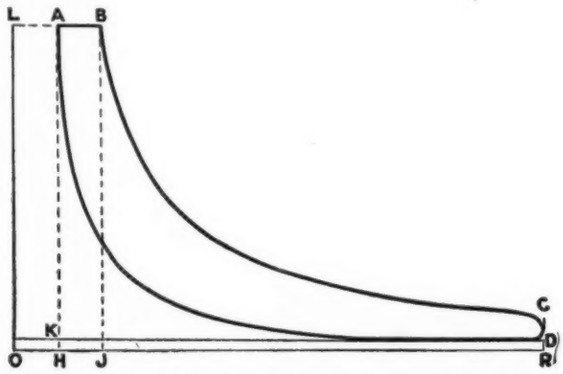


FIG. 1. INDICATOR DIAGRAM OF STANDARD DIESEL CYCLE

The condition in the oil engine is somewhat different, as here there is a necessity of losing part of the heat of combustion to the jacket cooling water in order to keep the temperature of the iron walls below a dangerous temperature, while with the steam engine there is necessity of keeping as much heat within the cylinder as possible. If there is to be any advantage derived from compounding the Diesel oil engine, it must be based on other grounds than those which apply to the steam engine. A brief investigation into the several events that take place in an oil-engine cylinder will reveal certain facts that must determine the advisability or non-advisability of compounding.

A typical Diesel indicator diagram, which shows a horizontal or constant combustion line, is illustrated in Fig. 1. It must be understood that this is somewhat ideal and that the actual diagram departs more or less from this outline, but this in no way destroys the merits of the following discussion. In this diagram we have the fuel admitted and burned during the portion of the stroke represented by *AB*. At *B* the fuel valve closes, or cutoff takes place, and the burnt gases expand from *B* to *C*. At *C* the exhaust valve opens and the gases blow out of the cylinder at constant volume and with a decreasing pressure until the cylinder pressure reaches that of the atmosphere at the point *D*. The suction and the exhaust strokes of the piston practically cancel each other, and they are eliminated here for purposes of clearness. The charge of fresh air is then compressed from atmospheric pressure at *D* to the final compression pressure at *A*, which will range from 475 to 550 lb. absolute. The expansion and compression curves have the form $PV^n = \text{constant}$, and n may be

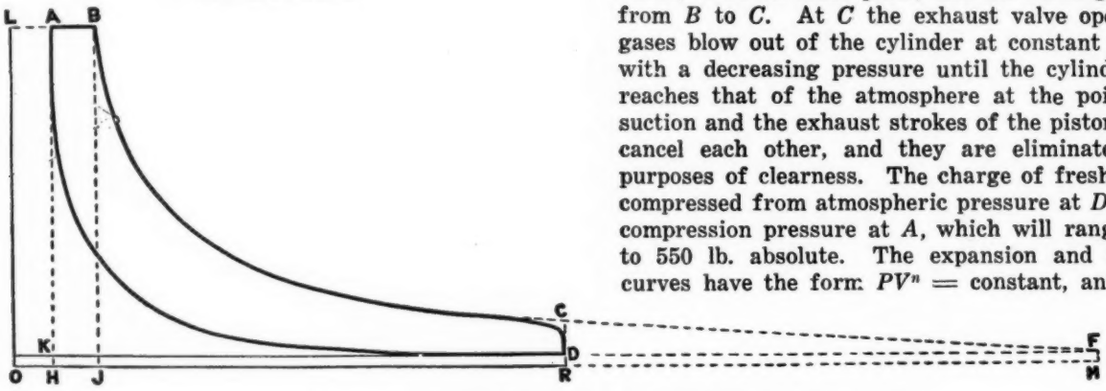


FIG. 2. ENERGY RECOVERED BY COMPLETE EXPANSION

In the steam engine the gain in thermal efficiency by compounding is due to the reduction of cylinder condensation, for it is possible to get as many expansions in a single-cylinder as in a compound engine if condensation is ignored. For example, a 30 x 42 Corliss engine with 12 expansions will give as much power as a 15 x 30 x 42 compound engine with the same number of expansions and, ignoring condensation, will be as efficient. That compounding is an advantage is due to the smaller heat range in the two cylinders. For example, if the steam is expanded in one cylinder from 150 lb. absolute pressure to 15 lb. (zero gage) absolute pressure the temperature of the steam drops from 358.5 to 212 deg. F. When the high-pressure steam enters the cylinder, the walls of which are at a temperature considerably below that of the entering steam, a material amount of condensation takes place. By dividing the expansion between two cylinders, the temperature range is cut in half, reducing condensation losses and decreasing the amount of steam per horsepower.

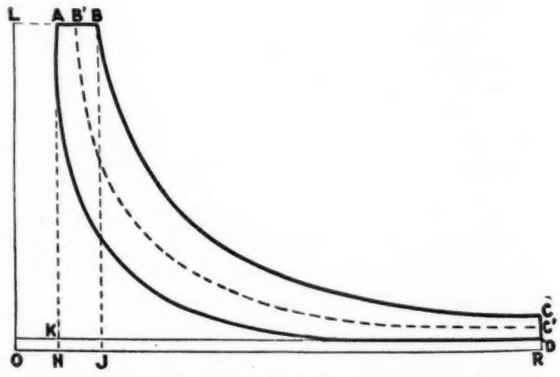


FIG. 3. EFFECT OF SHORT COMBUSTION PERIOD

taken as 1.35. As with any form of reciprocating engine, the indicated work performed in the cylinder is proportionate to *ABCD*, the area of this diagram.

If now the cylinder were made sufficiently long, the

gases in expanding from *B* to *C* could continue during the rest of the stroke, from *C* to *F*, Fig. 2, making the final expansion pressure at *F* equal to that of the atmosphere. This would be complete expansion, and the area obtained would be that of the diagram *ABCFDA*. The area *CFD* has been added to the standard diagram by complete expansion and represents energy that is thrown away in the average engine. It would appear at first glance that the saving of this area should prove that complete expansion is of advantage.

However, in engine construction we are dealing with a certain definite volume—that of the piston displacement plus the clearance volume. In the incomplete-expansion engine shown in Fig. 1, which gives the diagram *ABCDA*, this volume is proportional to *OR* and is the volume that should be used when comparing complete and incomplete expansion, or simple and compound engines. In making the computation in this article, this volume has been assumed to represent 100 cu.ft. With the compression curve following the same law as does the expansion, the volume at *A* would be 7.84 cu.ft. if the pressure is 480 lb. absolute.

Suppose now, as shown in Fig. 3, instead of having the fuel valve closed at *B* we have it closed at *B'*. This will give a terminal pressure of *C'*, which is considerably under the terminal pressure *C* of the standard diagram, and the expansion is nearer complete than in the standard diagram *ABCD*.

It will be noted that the work area obtained from a cylinder having a given stroke volume is decreased, although the efficiency has increased, owing to the partial saving of the energy that is usually thrown away, due to incomplete expansion. With a still shorter cut-

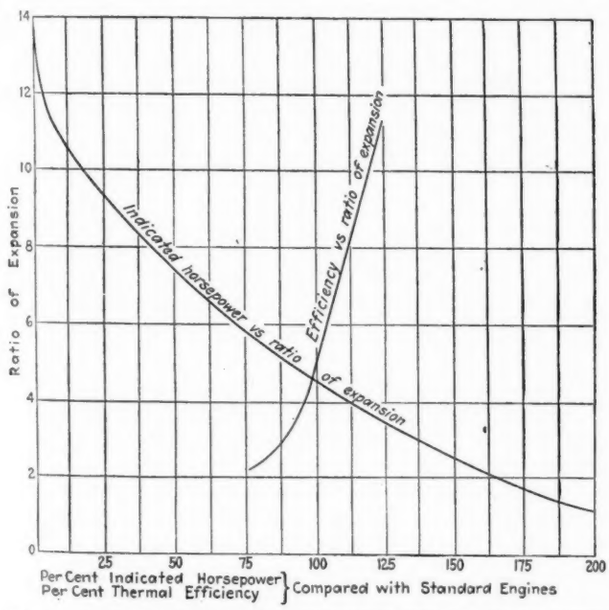

Ratio of Expansion
Indicated horsepower vs ratio of expansion
Efficiency vs ratio of expansion
Per Cent Indicated Horsepower
Per Cent Thermal Efficiency
Compared with Standard Engines

FIG. 4. EFFICIENCY AND HORSEPOWER WITH VARYING RATIOS OF EXPANSION

off the diagram is again reduced with a slight increase in efficiency. If the cutoff be shortened so that the terminal pressure *C* at the end of the stroke is atmospheric, or that represented by *D*, then the expansion stroke must follow along the same line as the compression stroke; that is, the expansion line will coincide with *DA*. No work then is obtained from the engine, for the expansion and compression lines coincide, and this means that no fuel can be introduced into the cylinder with complete expansion and complete compression. This probably would not quite hold true in the working engine, owing to the fact that there is a slight difference between the expansion and the compression line; but the argument is valid, in spite of this slight discrepancy.

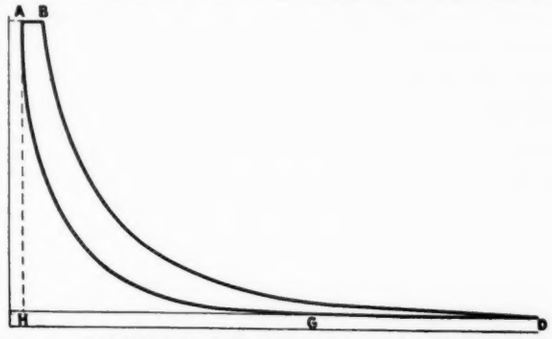


FIG. 5. COMPLETE EXPANSION WITH COMPRESSION STARTING AT LESS THAN THE STROKE VOLUME

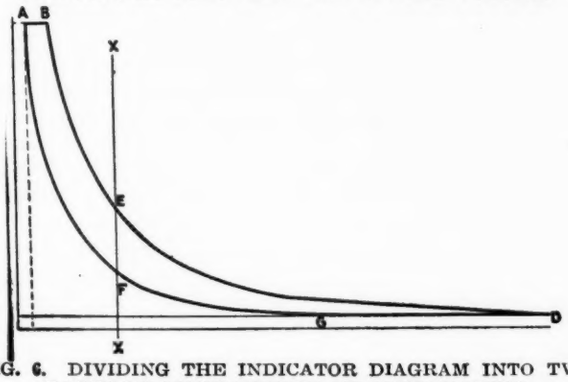


FIG. 6. DIVIDING THE INDICATOR DIAGRAM INTO TWO PARTS TO SHOW EFFECT OF COMPOUNDING

In Fig. 4 is shown a chart giving the increase in efficiency and the decrease in indicated horsepower with an engine of a given cylinder volume when the ratio of expansion is changed. In this chart the efficiency and the indicated horsepower of the standard Diesel with 60 lb. final pressure at *C* is taken as 100 per cent. This chart will show that as the number of expansions is increased, the efficiency increases, but the indicated horsepower decreases at a greater rate. With 11 expansions the efficiency is increased about 20 per cent, but the horsepower has decreased 85 per cent. With an expansion ratio of 13⅞, which gives complete expansion and complete compression, the indicated horsepower becomes zero.

It is apparent, then, that complete expansion at least is not possible in an engine where the compression is complete; that is, where the volume of air taken in on the suction stroke equals at atmospheric pressure the stroke volume of the engine. If, however, as shown in Fig. 5, the amount of air taken in is proportional, not to *HD* but to *HG*, which is somewhat less, then the compression stroke will not be *DA*, but will follow the line *GA*, and the expansion will follow *BD*. With complete expansion and incomplete compression we have the area *ABDG*. This shows that there is work developed in the engine by complete expansion when the volume of air taken in is less than the stroke volume of the piston, but the work is far less than will be developed in the cylinder operating on the standard cycle.

There is a minimum clearance volume under which it

is impossible to have the engine operate, since the rapid cooling from the excessively large surface area, as compared to clearance volume, prevents the engine from reaching an igniting temperature. This clearance volume would probably be somewhat above 3 per cent of the cylinder volume of the engine. Furthermore, the stated amount of air must be drawn into the cylinder to combine with the fuel, and the minimum amount should not be under 70 per cent of the volume, which would fairly check with the minimum clearance. Taking 3 per cent as the minimum clearance volume, the horsepower output of the engine with complete expansion will be only about 30 per cent of the horsepower output of the standard Diesel, but the efficiency will be approximately 22 per cent greater. We have in this case a small horsepower output for a large cylinder volume if the expansion is carried out in one cylinder.

If at some point, as *E*, Fig. 6, a vertical line *XX* be passed through the indicator diagram, we have in the left-hand portion a maximum pressure of 480 lb., and in the right-hand part of the diagram we have the maximum pressure at *E* of, say, 200 lb. In addition, we have a high mean effective pressure in the diagram at the left and a low mean effective pressure in that part of the diagram to the right of the line. If now it were possible to have the events indicated in the left-hand part of the diagram take place in a cylinder built for high pressures and have those shown by the right-hand part occur in a cylinder of large volume, but built to withstand, say, 200 lb. pressure, obviously the weight of this low-pressure large-volume cylinder could be less than that of the cylinder whose volume is the sum of the two volumes, but which must be built to withstand 480 lb. In addition there would be less heat loss during compression in the high-pressure cylinder due to the more favorable volume-surface ratio. The temperature drop in the receiver would, however, more than offset this advantage and would require a higher compression pressure to give an igniting temperature.

Complete Expansion Impossible

Of course, in an actual compound engine it is impossible to have the expansion complete to the atmosphere, owing to the fact that there is considerable resistance to the valve and exhaust passages, but probably the pressure at exhaust would not be more than 5 to 10 lb. gage. This would tend to increase the amount of air used per stroke, giving a somewhat greater horsepower than that anticipated with complete expansion, but would lower the efficiency to some slight extent.

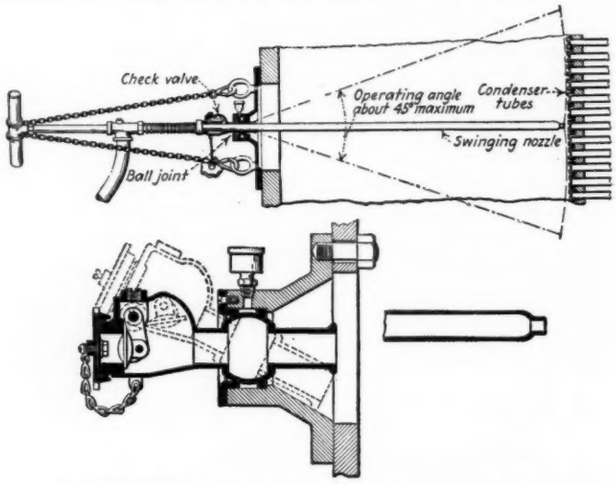
The conclusion is, then, that the compound engine cannot deliver as great a horsepower per unit of cylinder volume as is obtained in the standard Diesel. If the same degree of expansion is attempted in a single cylinder, the latter will deliver the same horsepower as the compound, but the compound would probably weigh less than the single cylinder.

In order to obtain the same output from the compound engine with 5 lb. back pressure as from the simple standard Diesel having the same compression and 45 lb. back pressure, it will be necessary to have the volume of the two compound cylinders over twice the volume of the single-expansion engine. It is a matter for the designers to determine whether the high-pressure and the low-pressure cylinders of the volumes indicated can be built lighter than the cylinder or cylinders of the standard Diesel and whether the gain in efficiency will justify the increased cost.

This argument does not apply to an Otto cycle when a mixture of air and fuel is compressed. Here the final compression pressure is limited by the temperature rise. By compounding, the charge may be compressed, cooled to its initial pressure and again compressed to a high pressure, but with a final temperature low enough to prevent preignition. In this way the pressure ratio is made large and the horsepower output is increased as is also the efficiency, but the maximum pressure against which the engine must work is much greater than in the standard engine, calling for a heavy construction which may offset the gain in power and efficiency. The gas-air mixture engine does offer greater inducements to compounding than does an engine in which only air is compressed as the Diesel or solid-ignition Otto-cycle engine.

Worthington Condenser-Tube Washer

To meet the need for cleaning out the tubes of surface condensers as often as desired without interfering with their operation, the Worthington Pump and Machinery Corporation, 115 Broadway, New York City, has developed a tube washer consisting of a long water nozzle, or lance, which, after the necessary attachments have been made, may be inserted into the condenser through the different manhole plates and swung around each time so as to force a rapid stream of water through every tube in the condenser.



A WASHER THAT CLEANS CONDENSER TUBES UNDER FULL VACUUM

The water-jet tube is inserted through attachments in the different manhole plates and swiveled about so as to force a stream of water through each tube in succession.

A section of the condenser with the apparatus in place is shown in the illustration, at the top, and at the bottom is shown one of the attachments that is placed upon each of the manhole plates. This attachment consists of a socket that swivels upon a ball-and-socket joint and through which the lance is inserted with a fairly close sliding fit. The shape of the end of the nozzle is shown at the lower right.

To use the device the operator pushes the long water nozzle into one of the attachments until he can hitch the four chains into the eye-bolts, as shown in the illustration. A spring between the attachment and the connection of the hose to the lance keeps the chains taut and the nozzle in its correct position, with its end very close to the ends of the condenser tubes.

The outer end of the lance is then swung around this way and that so as to force a stream of water (about 60 gal. per min., 250 lb. pressure) through the different tubes, one after another. The nozzle end does not move in arcs, but is made to move more nearly in a plane surface by the action of the four chains; when the outer end of the pipe is pulled over to one side the chain attached to the eye-bolt on the opposite side pulls it through the socket a little way and so tends to keep the nozzle end fairly close to the tubes.

When the tubes in front of one manhole plate have been cleaned, the lance is withdrawn, and the water in the condenser is prevented from escaping by a check valve shown in the closed position at the bottom of the illustration. A cap on the end of a short chain is then screwed on to make sure that the joint will be tight.

The operation is repeated for each manhole, and the manufacturers claim that about five minutes' work in each position is enough to clean the tubes in front of each plate. Best results, it is said, are obtained when the tubes are washed out daily and when the direction of flow of the washing jet is the same as the flow of circulating water. The apparatus is designed so that it can be attached to the manhole plates or flatheads of condensers already installed.

A Quick Method of Finding Required Lap on Slide Valve

BY ROBERT GRIMSHAW

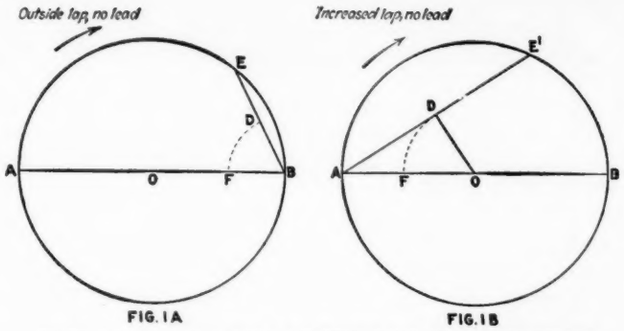
In preparing men to pass the examination for the Boiler Squad of the New York Police Department, I found that most of them were ignorant of the slide-valve diagram. It appeared that the usual Belgram or Zeuner diagram was entirely too confusing for the average engineer. A simpler method of finding the steam and exhaust lap for any desired cutoff or compression was gotten up, and is grasped without any great mental effort. To show the application of the system, the following problems of valve setting will be explained:

Problem I. To find the amount of steam lap required to have the engine cutoff at any desired point in the piston stroke.

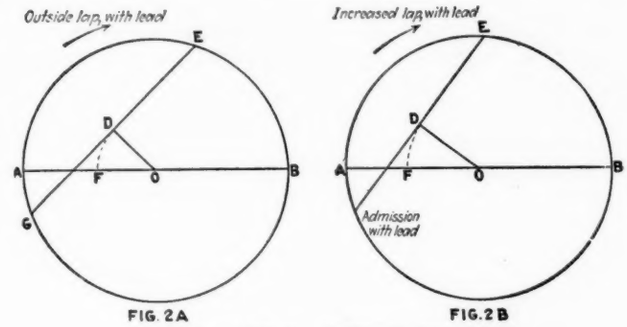
Draw a circle with a diameter *AB*, Fig. 1A, equal to the valve travel in inches. This circle also represents the crankpin circle regardless of the actual length of the crank, and the diameter *AB* is proportional to the piston stroke. The position of the crankpin when cut-off takes place, is indicated by the point *E* on the crank circle. Draw the chord *BE* as shown in Fig. 1A. Divide this into halves at *D*. The length *BD* is then the steam lap necessary to give cutoff at the crankpin pisition *E* if there is no lead.

The steam lap may also be found, Fig. 1B, by drawing the chord *AE'* instead of *AB*. Erect a perpendicular line *OD* from *O* to *AE'*. The length *OD* or *OF* is equal to the steam lap, and *AF* is equal to the maximum port opening. In Fig. 1B the steam lap has been increased and the resulting earlier cutoff at *E'* is shown.

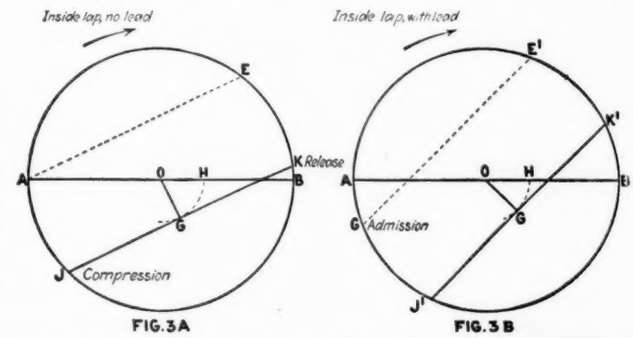
Problem II. Suppose the valve has a steam lap equal to *OF*, Fig. 2A, and it is desired to find the point of cutoff if the eccentric is set to cause the valve to open where the crank is at *G*, Fig. 2A. With the steam lap *OF* as found in Fig. 1, construct the arc *FD* as shown. Draw the line *GE* tangent to the arc *FD*. The point *E*,



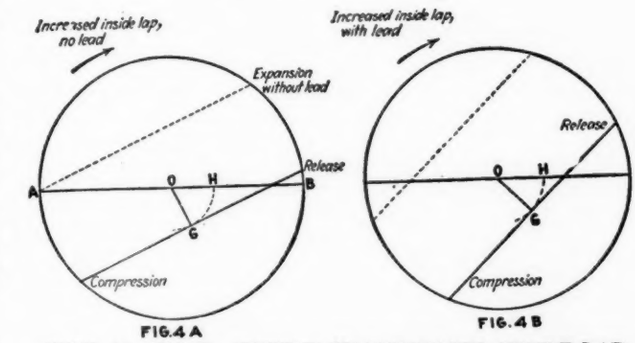
FIGS. 1A AND B. EASY METHOD OF FINDING POINT OF CUT OFF



FIGS. 2A AND B. EFFECT OF LEAD



FIGS. 3A AND B. FINDING RELEASE AND COMPRESSION WITH A GIVEN LAP



FIGS. 4A AND B. EFFECT OF INCREASED INSIDE LAP

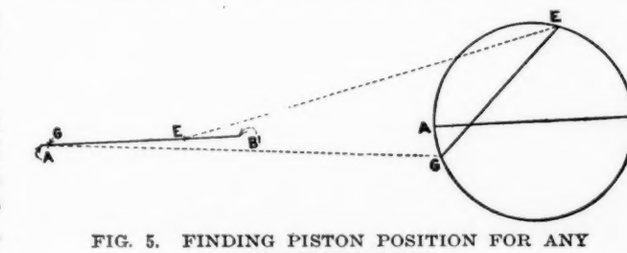


FIG. 5. FINDING PISTON POSITION FOR ANY CRANK POSITION

then, is the position of the crankpin for cutoff when the valve has lead.

If, now, the lap is increased as indicated in Fig. 2B, while the admission is held at the same position G of the crank, then the new crankpin position for cutoff will be E^1, Fig. 2B.

Problem III. To show the effect on the release and compression of shifting the eccentric to give lead with the same steam lap as with no lead, Figs. 3A and 3B are shown. In Fig. 3A there is no lead and cutoff takes place at the crankpin position E, the same as in Fig. 1A. If the exhaust lap is equal to OH, by drawing OG^1 perpendicular to AE through the center O, the intersection of the arc and OG is at G. Drawing the line JK through G perpendicular to OG, the crankpin position K for release and its position J for compression are found.

If the eccentric is shifted to have the admission occur when the crank is at G, cutoff occurs at E^1 while release is now at K^1 and compression at J^1 as in Fig. 3B.

In Figs. 4A and 4B is shown the influence of more inside or exhaust lap, which causes release and compression to be earlier.

The points determined are positions of the crankpin. To find the piston position, it is necessary to lay off AB^1 the piston stroke, at a distance from the crank circle AB such that BB^1 is equal to the connecting-rod length. By striking an arc with a radius equal to the connecting-rod length, the piston position corresponding to the crankpin position for any of the events as herein outlined, may be quickly determined.

What Happens Inside of the Water Leg?

BY W. J. FOWLER

Many expedients have been tried to determine what the conditions might be in the restricted water legs of vertical boilers, chief among these being the small mirror held on a bent rod. Even under these conditions, however, it is extremely difficult to more than approximate the condition of the firebox sheet and the staybolts. As a rule the furnaces of this type of boiler give notice of the condition on the water side of the plates by continued leakage and sometimes by distortion.

It is rarely, however, that one is able to obtain such conclusive proof of what may and frequently does take place in the water legs of boilers under operating conditions, as is demonstrated by the accompanying illustrations.

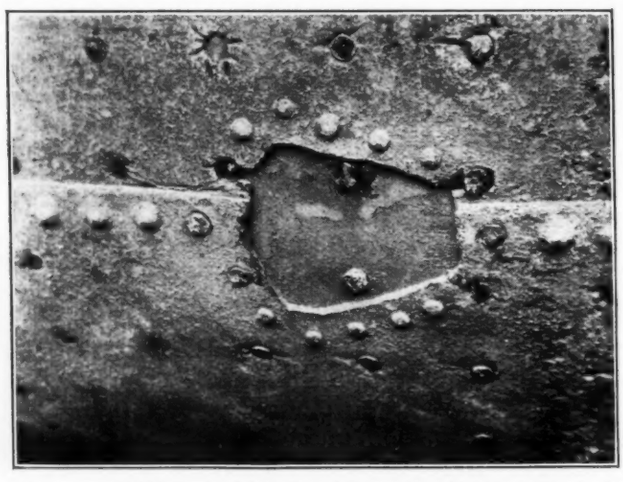


FIG. 1. SHOWS GROOVING AND BREAKING AWAY OF PLATE FROM THE STAYBOLT AND PATCH-BOLT HOLES

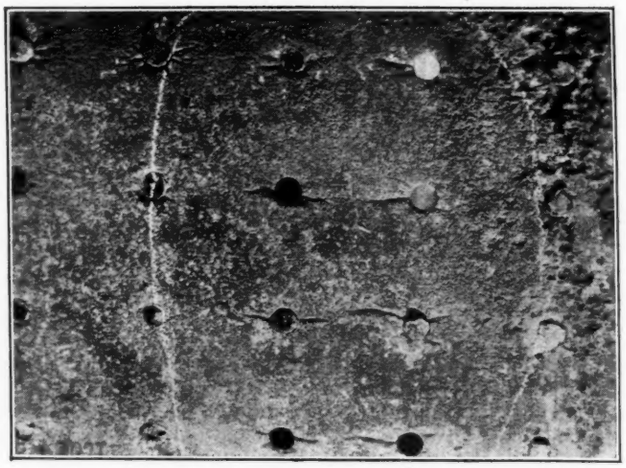


FIG. 2. SHOWS LONGITUDINAL CRACKS RADIATING FROM THE STAYBOLT HOLES

Fig. 1 shows a section of the water side of the furnace sheet of a logging donkey after it had been removed from the boiler. Here we have a substantial illustration of almost every known form of deterioration that can take place on boiler plate. On the extreme right of the picture is shown excessive corrosion; this was close to the mud ring. To the left of the patch can be seen a marked instance of grooving. It is also shown where the original furnace wall has cracked out from some of the staybolt and patch-bolt holes. This furnace sheet had been in operation only about six years under a pressure of 160 lb. and the water in use is considered good for boiler purposes.

In Fig. 2 is clearly shown the excessive corrosion at the right of the picture and the severe cracking that has taken place from the staybolt holes. The longest of these cracks runs in a longitudinal direction, clearly demonstrating the direction of the major strain. One remarkable feature about this furnace sheet is that, when removed, over 60 per cent of the staybolts were found to be broken and yet the furnace had not shown any sign of distortion or movement toward collapse.

The question that naturally arises is, How much longer would the furnace have stood the working pressure without collapsing, and would the collapse have been accompanied by extreme violence or only by sufficient leakage from the opened cracks to relieve the pressure.

Collapse of a Famous Chimney

Last month a disaster occurred during the demolition of a factory chimney belonging to Messrs. Charles Tennant and Co., Ltd., the well-known chemical manufacturers, in the St. Rollox district of Glasgow. Only about 100 ft. of the chimney remained, the demolition having been going on for several months, when suddenly the outer shell collapsed and four men were killed and four others injured. This chimney was famous as being the tallest ever erected in the British Isles, 453 ft. in height. It was built in 1842 at a cost of over £12,000. A number of years ago it was shortened as cracks were observed in the upper portion, and a further reduction to 350 ft. was made in 1903.

Finding the Developed Horsepower of an Engine

BEFORE going into the method of finding the horsepower developed within the engine cylinder by measuring the indicator diagram, it is well to review the meaning of *force*, *work* and *power*.

Force may well be defined as that which either causes motion or tends to either cause or prevent motion. Suppose we have a cylinder, Fig. 1, filled with a gas at some pressure such as 100 lb. per sq.in. and the cylinder fitted with a frictionless piston. The gas, if not opposed by some external force, would expand and push the piston out of the cylinder. If the cylinder had a cross-sectional area of 1 sq.ft. (144 sq.in.), then to prevent the expansion of this gas we must load the piston with 144×100 or 14,400 lb. This weight just equals the pressure exerted against the piston by the gas. The gas pressure is evidently, by definition, a force since it tends to push the piston, and likewise the attraction of gravity on the weight is also a force since it tends to push the piston inwardly. These two forms are opposite and equal, and as long as this condition exists the piston will not move.

If the amount of weight holding the piston down be reduced, the force exerted by the gas upon the piston will be greater than the opposing force due to the weight, and the piston will move upward. The force P exerted by the gas over a distance S has then performed work. Work is, then, *force times distance* or may be expressed as $W = FS$. This is similar to what takes place within the engine cylinder, Fig. 2, when the pressure exerting force upon the piston causes the latter to move and by a suitable connecting rod, crank and pulley wheel does work by driving machinery, etc.

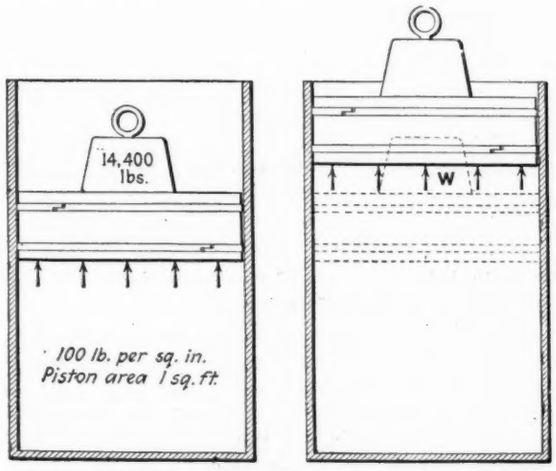


FIG. 1. WORK BEING DONE IN LIFTING WEIGHT

Work is equal to force times distance, and if pounds and feet are the units used, it is measured by a unit called a foot-pound. It will be noticed that the rate at which the force moves does not enter into the amount of work done. There is just as much work done in lifting 100 lb. from the floor to a height of 100 ft. at the rate of 1 foot per day as there is in lifting it at the rate of 1 foot per second.

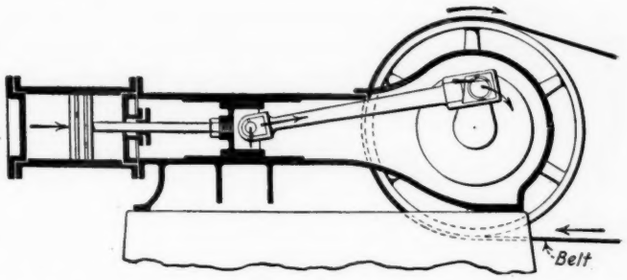


FIG. 2. ACTION OF THE FORCES IN A STEAM ENGINE

The element of time enters when considering the *power* developed in doing work. Power is, then the rate of doing work. James Watt, when installing his steam engine to replace horses in the English mines, wanted some scale of comparison of the engine power with that of the draft horses. In order to have an excess of power he rated his engines on the basis of lifting 550 lb. 60 ft. in one minute or 33,000 lb. a vertical distance of 1 ft. in one minute, this being somewhat more than the mine horses could do. He called this rate of doing work *one horsepower*.

THE horsepower developed by an engine depends upon the total pressure acting on the piston and the piston speed. This article deals with the process of computing the indicated horsepower.

The horsepower is, then, a rate of doing work equal to the lifting of 33,000 lb. one foot per minute. This is likewise equal to a rate of 550 ft.-lb. per second or 1,980,000 ft.-lb. per hour. This is the standard unit employed in English computations. When the metric system is used, obviously the unit of power is different.

As pointed out in previous articles the indicator diagram gives us a means of finding the horsepower developed by the engine. Having found the mean effective pressure or average forward pressure by the planimeter or by any of the several mean-ordinate methods, the work done per stroke is the product of this pressure per square inch exerted against the piston times the area of the piston in inches (to obtain the total pressure) times the distance the piston is moved by that pressure. The work done per stroke in foot-pounds is then Pla, where

P = m.e.p.;
l = stroke in feet;
a = piston area in square inches.

The power developed in one end of the cylinder per minute is the product of the work Pla and the number of times the piston is forced forward by the pressure in this end of the cylinder or

$$Power = work\ per\ minute = Plan$$

where n is the number of forward strokes or the number of revolutions per minute.

Since one horsepower equals 33,000 ft.-lb. per minute, one end of the cylinder will do work at the rate of $\frac{Plan}{33,000}$ horsepower. Assuming that the m.e.p. (P in above expression) is the same for both ends of the cylinder, the engine will do work at the rate of $\frac{Plan}{33,000}$ when n is the number of strokes per minute. Twice the revolutions equals the number of strokes per minute. The length of the stroke times this number equals the piston speed S. So that the horsepower developed by the engine is

$$Hp = \frac{PAS}{33,000}$$

when P is the average of the two mean effective pressures or $\frac{P_h + P_c}{2}$ when P_h is the mean effective pressure of the head end and P_c is that of the crank end.

Notice that the "piston speed" as used in these formulas and in this connection is not the average speed of the piston or the distance through which it passes in a minute, but the distance through which it is urged by the m.e.p. under consideration. The piston speed, in this sense, of a single-acting engine will be, for instance, one-half of that of a double-acting engine of the same length of stroke running at the same number of revolutions per minute notwithstanding the pistons of both engines travel at the same average speed, because, in the single-acting engine, the pressure is acting only one-half of the time.

For any given engine the piston area is constant, and for an engine running at constant speed $\frac{AS}{33,000}$ is constant regardless of the m.e.p. and the horsepower. This expression $\frac{AS}{33,000}$ is called the engine constant and after once being found permits the rapid calculation of the horsepower developed in the engine. To find this constant, or the horsepower per pound of mean effective pressure:

Rule: *Multiply the piston area in square inches by the piston speed (stroke in feet $\times$ 2 r.p.m.) in feet per minute and divide by 33,000.*

Example: Suppose we have a double acting 17 x 36-in. engine running at 150 r.p.m. and with a m.e.p. of 60 lb. the piston speed will be

$$2 \times 150 \times \frac{36}{12} \times = 900 \text{ ft. per min.}$$

The piston area is 0.7854 (d^2) where the diameter d is 24 in. or $A = 226$ sq.in. The engine constant is

$$\frac{AS}{33,000} \text{ or } \frac{226 \times 900}{33,000} = 6.163.$$

The horsepower developed by the engine is

$$Hp. = m.e.p. \text{ (engine constant)}$$
$$= 60 \times 6.163 = 369.78$$

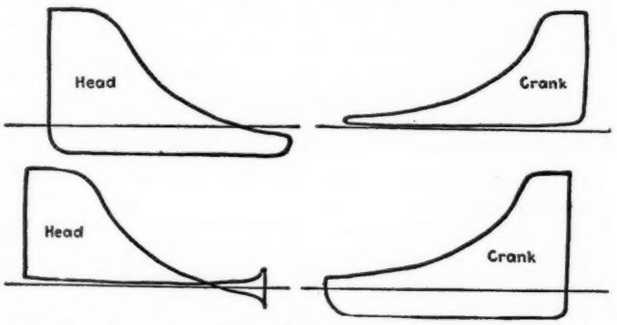
For accurate work the area of the piston rod, and of the tail rod when one is used, should be subtracted from the piston area. When a tail rod of the same diameter as the piston rod is used, the area due to their diameter may be subtracted from the area of the piston, and this reduced area used in the $\frac{Plan}{33,000}$ formula. When the effect of only the piston rod is to be allowed for, subtract one-half its area from the area of the piston and use the difference for a of the formula. When there is a tail rod of a diameter different from that of the piston rod, add their areas together, divide by 2 and subtract the quotient from the piston area.

If it is desired to know the power developed by each end of the cylinder separately, find the horsepower constant for each end by the foregoing rule, or use the formula

$$Hp. \text{ per lb. } m.e.p. = \frac{area \times piston\ speed}{33,000}$$

correcting the area for the piston or tail rod for the end in question and using one-half the piston speed as it would be computed for the whole cylinder.

In this discussion the so-called mean effective pressure has been used. While the total horsepower of the engine will be the same, in fact the horsepower developed in a particular cylinder end, say the head end as measured from the diagram from that end alone, is based not upon the m.e.p., but upon the mean difference between the head-end forward pressure and the crank-end back pressure. Fig. 3 shows two indicator diagrams which in Fig. 4 have been corrected to show the real pressure difference by deducting the crank back pressure from the head-end forward pressure.



FIGS. 3 AND 4. INDICATOR DIAGRAMS WHICH ARE CORRECTED IN FIG. 4 TO SHOW THE REAL NET FORWARD PRESSURE

In balancing engines this is of some importance, and the power of the two ends should be equalized as nearly as possible. The crank end suffers from the piston-rod area, so its average mean pressure should be higher than the head-end pressure if the load is to be evenly distributed.

The absolute pressure of vapor or steam over water in a closed vessel depends only on the temperature of the water and is the pressure given in the steam table for that temperature. For example, if the temperature of the water is 102 deg., the vapor pressure is 1 lb. absolute, which is approximately the same as a 28-in. vacuum (on a 30-in. barometer). Why is it, then, that in a condenser where the condensate is at 102 deg., the vacuum is always lower than 28 in. (or the absolute pressure higher than 1 lb.)? The answer is that air is present. The total pressure produced by any mixture of gases or vapor is the sum of the pressures that each would exert if it filled the space alone. There is always some air mixed with the steam in the condenser, and its pressure is added to that of the vapor.

EDITORIALS

Operating Engineers Increase in Numbers

THERE are over 242,000 stationary engineers in the United States, according to the Census figures recently issued. This is an increase of eleven thousand in ten years, which is significant in view of the assertion so often heard that extension of central-station service is driving many operating engineers out of employment. The answer, of course, is to be found in the great industrial growth of the country. This is further attested by the fact that the last five years of this period has witnessed an increase of over two million horsepower installed in private plants and three times that amount in central-station capacity.

Coming to the number of firemen employed in stationary plants, as reported from the same source, one comes upon another apparent paradox. It is generally recognized that the use of mechanical stokers has increased greatly during the last few years, yet the number of firemen rose from 111,248 in 1910 to 143,875 in 1920—an increase of over thirty-two thousand. Here again the explanation is industrial expansion taken in connection with increased central-station service; for in most industrial plants running on purchased power, there are boilers supplying steam for heating and some industrial processes. These boilers, where operating at low-pressures, are frequently hand-fired.

Thus it would appear that the operating engineers and firemen are in little danger of becoming extinct species, unless the fact that there are thirty-two women employed as stationary engineers may be taken as an indication of intrusion by the fair sex.

Determine Reasons as Well as Results

IN A recent discussion of the subject "Judging Coal Values," G. B. Gould gives an excellent example of the wrong way to proceed and sounds a warning most effectively against dealing only in fragmentary information instead of proceeding to broad general engineering conclusions. He states: "The purchasing agent of a large manufacturing company was discussing the choice of coal. In the course of the conversation he remarked that his plant could not use a certain coal, naming it; they knew that because they had tried it. When asked why they could not use that particular coal, his only reply was that it would not make steam enough. This, of course, was only stating a result, not a reason, and out of that experience he had not learned anything which would enable him to avoid other coals having the same characteristics."

This failure to dig deeply enough into any test to find the underlying principles involved is not characteristic of fuel tests alone. Unfortunately, it is altogether too common a fault in many power plant trials of equipment as well as of fuel. Experimentation is always worth while. Only by trial can one really determine how to make progress. But experimentation should be systematic, and the conclusion drawn from tests should be made as broadly significant as possible.

By this generalization it is not intended to imply that a person can make one test and then proceed to generalize from it. But the full meaning of each test should be obtained rather than only the perfunctory obvious conclusion that a certain apparatus or fuel is good, bad or indifferent.

The basis of engineering judgment is the accumulated experience properly *systematized* so that it may be applied to any new problem that may arise. This means accurate records, thorough analysis of "the reason why" certain phenomena are observed, and then co-ordination of all experiences into a systematic understanding of the power-plant problems as a whole.

Anything that will add to the ability of an engineer to form sound technical decisions is worth while; but unless the reason underlying a phenomenon is understood, the facts alone are not likely to be particularly useful. As Mr. Gould says later in his same discussion, one should not attempt to secure "an isolated fragment of information" when he can as well obtain from his experience "a fact capable of profitable application to many future decisions." One who follows the former course is not likely to progress far. He who adopts the broader policy will become the real engineer with a groundwork of science as well as of experience.

Wanted—A Job

THE Federated American Engineering Societies is all set and ready to function. All that it needs now is something to do.

It was organized "to further the public welfare wherever technical knowledge and engineering experience are involved, and to consider and act upon matters of common concern to the engineering and allied technical professions."

There is to be an international exposition at Philadelphia in 1926 to celebrate the sesqui-centennial of the Declaration of Independence. It has been proposed that there be held in connection with this exposition an international Engineering Congress. What more logical body than the Federated Engineering Societies could be conceived to undertake the organization of such a Congress, to make it something to look forward to, something capable of enlisting the interested co-operation and contribution of the world's best engineering thought, something that would be a milestone in the record of engineering progress?

It is not too early to get actively about it.

The Muscle Shoals situation is of national interest. Its correct solution is of more than ordinary import to the public welfare. Numerous groups are actively engaged in cultivating public sentiment and seeking legislative favor for settlements favorable to their own interests. Nobody holds a brief for the public. If the collective disinterested opinion of the engineers of the country could be brought to bear upon the problem, it would be settled right. What better service could

the Federated American Engineering Societies render than to present a plain, impartial statement of the facts in the case, the questions involved, to inspire engineering consideration of them, to invite the expression of engineering opinion and to make it articulate?

A similar service might be rendered in the matter of the St. Lawrence project and the development of the Colorado River, both involving questions of more than local or sectional interest.

In matters bearing upon the profession itself there is the question of Engineers' License Laws. It has been objected that this is a movement having for its purpose the betterment of the condition of the individual or, if considered with reference to the profession, as affecting its material well being rather than its public usefulness. If this is even the ulterior purpose of engineers' license laws, they should be discouraged. Their only legitimate reason for being is the safeguarding of the public from incompetent and irresponsible practitioners. Is not the determination whether or not such governmental control of enginering practice is necessary to the public welfare and, if it is, how and to what extent it should be exercised "a matter of common concern to the engineering and allied technical professions"?

If these are not the sort of questions that the American engineering societies were federated to consider, what sort of a job are they looking for?

Motor Applications Require Careful Consideration

THE field of motor applications is becoming broader each year. Drives that previously were thought to be impossible for electric motors are being satisfactorily solved. In many cases the motor is giving better service than was obtained by any other method. As the characteristics of the different loads are better understood, special motors have been developed to better meet these needs. These have supplanted many of the older types with marked improvement in motor operation, reduction in maintenance costs and in power input per unit output as well as an increased output. As an example of this the modern high-torque alternating-current elevator motor not only has materially increased the speed of the service, but will do the same work with approximately forty per cent less power consumption than the early type of motors used in these applications.

Motor efficiency is something that should always be considered from the results produced in the application where it is used and not as applied to the motor alone. The motor that on test may show the highest efficiency may, when applied to certain classes of service, consume considerably more power than a machine having a lower efficiency on test but designed especially for the work. Where frequent starting and stopping are involved, low inertia and high starting torque are characteristics that will contribute more toward low power consumption and satisfactory operation than high efficiency. On the other hand, for continuous operation high efficiency may be an important factor in the power consumed by the motor. These conditions are sufficient to indicate that the application of motors needs careful consideration if low power consumption and satisfactory operation are to be attained. However, these are only three of the many considerations in the selection of motors, as discussed by Gordon Fox in his article "Selection of Electric Motors," on page 723 of this issue.

The alternating-current motor has made the question of proper loading one of prime importance. With an underloaded direct-current motor there are no bad effects as far as the system is concerned. If the motor is too large for the load, its cost will be higher than necessary and it may operate at a somewhat reduced efficiency, but these conditions may be offset to a degree by greater reliability and reduced maintenance charges. If an induction motor is too large for the load to which it is applied, not only will the efficiency be below normal and the cost of the motor unnecessarily high, but the power factor will be low. The latter results in increasing the load on all the equipment supplying power to the motor and has been the cause of the power companies penalizing the customer for low power-factor loads. Therefore underloaded induction motors not only operate at lower efficiency than motors that are loaded, but the cost per unit of power may be higher.

The Hell Gate Boiler Room

RELIABILITY, always a primary consideration in central-station design, is of particular importance in a station that is to serve New York City, where the power requirements are unusually exacting. With this in mind the designers of the Hell Gate Station have been progressive in matters involving economy of operation, while at the same time they have kept well within the already established limits of pressure, superheat and size of boilers.

Yet this conservatism in all vital matters does not mean that new ideas have not been incorporated where a gain in "dollar" economy, without any counterbalancing reduction in reliability, could be safely predicted after a careful engineering analysis. That this is the case is demonstrated by such features as the hydraulic ash-removal system, the three-inch boiler tubes, the sole use of alternating-current motors for driving the boiler-room auxiliaries, and the location of the superheater elements in the high-temperature zone beyond the sixth row of boiler tubes, with no baffles to shield them from the radiant heat of the furnace.

During the war tremendous interest was created in the development of means of destruction and devices for combating this equipment. During this period the general public was ready to believe the announcement of almost any impossible claims. For the last two or three years the world has been deluged with reports of inventors producing all kinds of impossible devices, which range from perpetual motion to the discovery that cockroaches transmit radio messages from their whiskers, or the finding of a living plesiosaurus in a South American lake. Is this an indication that we are approaching a period of greater scientific and engineering development, or is it all a brainstorm?

Too frequently in the design of power stations it is overlooked that the construction of the plant is accomplished under favorable circumstances with a large number of men, where the operation and maintenance has to be done with a small crew and in many cases under unfavorable circumstanees. It may require only a year or so to design and construct the plant, but the operation and maintenance goes on for ever. Therefore, construction difficulties are generally of short duration, but operating inconveniences may develop into a nightmare for those who have to keep the wheels going.

PRACTICAL IDEAS from PRACTICAL MEN

Adapting a Series-Wound Motor to Shunt-Motor Duty

In case the insulation is destroyed on the coils of bar-wound armatures, they may be used again after having been restored to their original shape by passing them over a form, by cleaning off the old insulation and applying new. Ordinarily, unsoldering the leads out of the commutator leaves them in pretty good shape

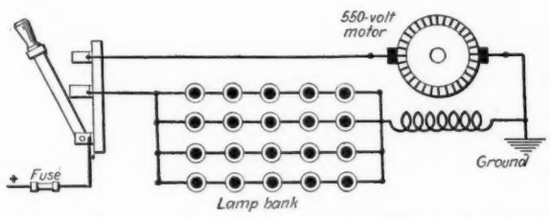


DIAGRAM OF A SERIES MOTOR CONNECTED TO OPERATE AS A SHUNT MACHINE

for retinning, but occasionally considerable time must be spent in scraping them to a surface satisfactory for retinning.

Scraping is a slow operation, and in order to eliminate it, it was proposed to apply a motor to driving a buffing wheel to assist in doing the scraping. A fabric wheel was used for the purpose, but its surface was previously given a coat of glue and then rolled in No. 60 emery. The only motor available was a 550-volt series-wound machine, and a trial disclosed that when sufficient resistance was connected in series with it to hold the speed at a safe value when the buffer was not working, the speed would be too slow when the buffer was in operation, therefore, the connections shown in the figure were adopted.

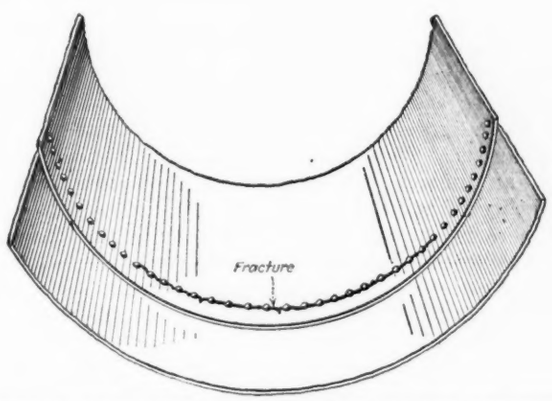
The full-load current of the motor was about one ampere, and it was found that the speed corresponding to the full load was about right to do the work. Experimenting determined that three series of five 110-volt 40-watt lamps connected in parallel with one another and in series with the motor field coil, gave an exciting current of about one ampere when the machine was operating on a 550-volt railway circuit. A fourth series of lamps was added as spare should one of the others give out in service. The arrangement of the switch is such that the blade makes contact with the middle jaw, to which the field circuit is connected, before it makes contact with the jaw to which the armature circuit is connected. This insures that the motor will have its field poles excited before the closing of the armature circuit—a decided advantage where a motor is started by throwing the armature directly across the line.

In actual operation the operator closes the switch slowly and makes certain that all the field-circuit lamps glow before pushing the blade to the position in which the armature circuit is closed. One man and this machine can do in one hour what formerly it took two men nine hours to do with scrapers.

Brooklyn, N. Y. E. C. PARHAM.

Hidden Fracture in Girth Seam

The stress per unit of length on the girth seam of a plain cylinder boiler, due to the pressure of the steam, is only one-half the stress in the same unit of length on the longitudinal seam. But if a number of holes are drilled in each head and a set of tubes put in and expanded in the holes, so as to act as hollow stay-rods,



SECTION OF GIRTH SEAM WITH FRACTURE BETWEEN THE RIVETS

the stress on the girth seam is reduced considerably less than one-half of that on the longitudinal seam.

This fact perhaps explains why an old horizontal return-tubular boiler continued intact for a number of years, under a daily working pressure of 70 lb., after the metal between the rivet holes in one of the girth

seams had been broken through for almost one-third the circumference of the shell, as shown in illustration.

The boiler was 60 in. in diameter. There were three ring courses in its shell. The fractured seam was the one that joined the forward and middle courses. As the boiler stood in the setting, this seam came a few inches back of the bridge wall.

For several years there had been considerable leakage from the forward girth seam when the boiler was cold; but when the boiler was fired up, all signs of the leak disappeared. The seam had been calked a number of times, and boilermakers had made several examinations of it, but were unable to discover the cause of the leakage. They assured the owner, however, that it was nothing to worry about. But the man in charge of the boiler, who still scented danger notwithstanding the boilermakers' assurances to the contrary, finally prevailed upon his manager to throw out the old boiler and install a new one.

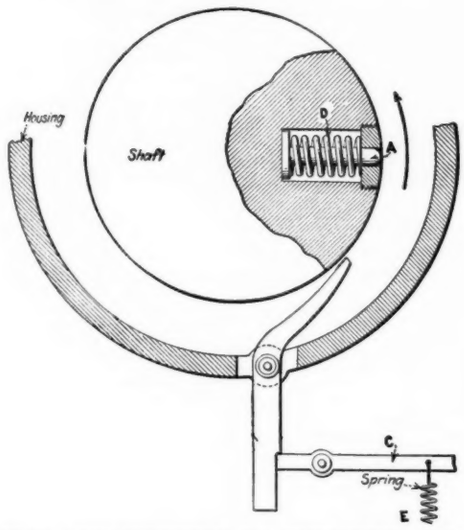
The old boiler was sold to a junk dealer who cut it up for scrap. While this operation was going on, the fracture was discovered. It was in the lap of the middle sheet and extended for nearly five feet along the line of rivet holes. The length of time the boiler had operated after the fracture occurred was evidenced by the fact that the edges of the fracture had been worn smooth by the abrasion between them as the boiler changed shape from expansion and contraction.

St. Louis, Mo. A. J. DIXON.

Greater Reliability Required in Steam Turbine Governors

In spite of the double protection afforded by the flyball governor and the special emergency governor which is supposed to operate when a safe speed is exceeded, there have been a regrettable number of accidents due to the bursting of rotors of steam turbines. Apparently, mishaps of this nature occur as frequently on small turbines as on large, which may be accounted for by the great number in use, negligence on the part of the attendant and the rapidity with which acceleration may occur. Standard specifications require the turbine to withstand a speed of 20 per cent above normal, and although no doubt a considerably higher speed is necessary to cause rupture, the fact remains that it is a comparatively easy matter for the turbine to attain an excessive speed through failure of the governor mechanism. This fact is recognized by the builders, and an emergency governor is furnished with the majority of turbines.

There is not much hope of lessening the danger by increasing the strength of the rotor or by decreasing its normal velocity. High velocities are necessary if steam economy is to be obtained, and as a rule the rotors are about as strong as they can be made with the materials available. Moreover, if the governor fails to function properly, it makes comparatively little difference if the rotor will stand an increase in speed of 20 or 100 per cent. Acceleration is likely to be so rapid that, even if the engineer's hand were on the throttle, it is doubtful if he would note the acceleration and get the steam shut off before the latter figures were reached, and the failure at a high speed will probably be more destructive than at a lower. The road to safety lies in the direction of more reliable governors being furnished by the manufacturer and more careful attention to and inspection of the governor mechanism by the operating engineer. Investigation following one explosion disclosed the fact that the engineer did not know that there was an emergency governor on his turbine. There are no doubt many plants in successful operation, up to the present, with engineers in the same state of blissful ignorance. There are many others that are practically as bad off; the engineer knows that the emergency is there and rests content with that knowledge. The flyball governor is usually a reliable mechanism; it is in continuous operation, which tends to keep the working parts free and gives warning of undue friction by slight irregularities in regulation. The working parts are, as a rule, strong enough for all ordinary emergencies. Eventually, the unforeseen occurs, a bit of foreign matter is caught in the governor valve and prevents its closing tightly, the valve in some inexplicable manner has become loosened on its stem or a pin or adjusting nut has worked loose. Only a small amount of steam is required to create an excessive speed at no load, and valve leakage



GENERAL ARRANGEMENT OF OVERSPEED TRIPPING DEVICE

that is unnoticeable while the turbine operates on its customary load may be sufficient to cause racing when all load is removed. It may be that the valve stem has been shortened (a rather risky practice) in order to obtain a greater valve opening or to increase the normal speed, with the result that the governor has not throw enough to close the valve properly. In any of these events the safety of the turbine depends on the emergency governor, which may or may not have been perfectly reliable when it left the factory, but in any event has probably suffered from a long period of idleness.

Instructions furnished with the turbine, which sometimes fail to reach the operating engineer, contain some few words concerning the advisability or necessity of an occasional trial of the emergency governor; but they do not seem to lay the emphasis upon the subject that it deserves. Frequently, they simply state that the emergency governor should be tripped by hand at regular periods; and in the large majority of cases it receives no other attention from the operator. This practice is of course better than total neglect, but it constitutes a test on only about one-half the emergency mechanism and perhaps the half that is least likely to fail.

A common form of tripping device is illustrated. The

turbine shaft is drilled to receive the plunger *A*, which is retained in the position shown by the spring *D*. When the centrifugal force becomes sufficient to overcome the initial tension of the spring, the plunger rises. The parts are generally so proportioned that when motion of the plunger begins, the centrifugal force increases more rapidly than the spring tension and it travels immediately to its most outward position. In its extended position the plunger strikes the trip lever which releases the lever *C* and allows it to be thrown over by the spring *E*, thereby closing, by any convenient intermediate mechanism, a separate valve in the steam supply. Various makes of governors differ considerably in detail, but adhere to the principle of centrifugal action against the pressure of a spring causing a movement that trips a lever communicating with the valve. In some types the mechanism is more readily operated by hand than in others; in the figure it is accomplished by a light blow on the exposed end of the trip lever. It will be seen that tripping by hand gives a reliable test in regard to the operation of lever *C* and its connections to the emergency valve. It is also a satisfactory test on the valve provided the turbine is running on no load at the time; it is, however, only a partial test on the trip lever and gives no indication of the operation of the plunger. On account of the high velocity of the plunger and the fact that it flies out suddenly, the blow on the inner end of the trip lever is rather violent, and as a result the pin that carries the lever may be bent or displaced, also the inner end of the trip lever may become worn, bent or even broken off. There is also the possibility of the plunger becoming bent and binding, or there is the rather remote chance that corrosion or foreign matter may prevent its operation. The united chances of failure from the foregoing causes are probably fully as great as from the causes that would be detected by hand operation.

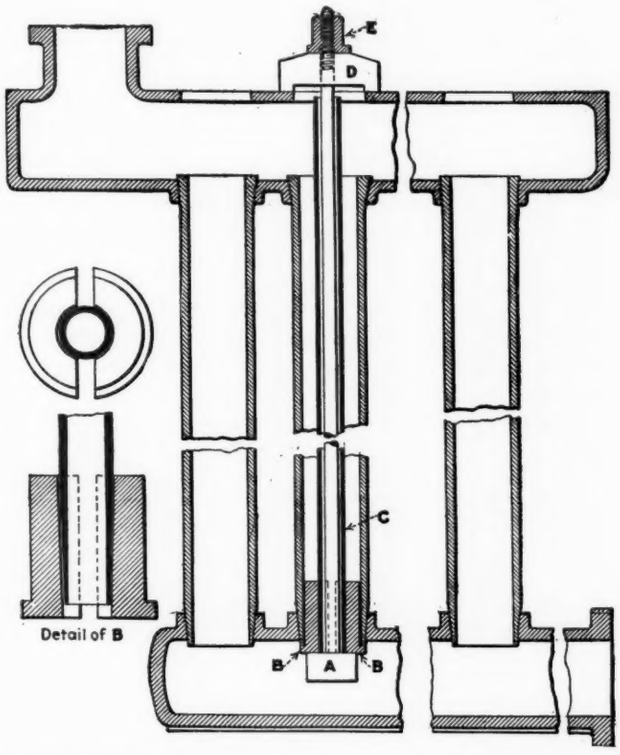
To give a fair assurance of safety, the complete governor mechanism should be tested at regular intervals. Turbines should be run on no load or the lightest possible load, in order to test the action of the flyball governor. The speed should then be increased until the emergency governor operates, or a speed 15 per cent above normal is attained; the emergency is supposed to operate on an increase of 10 per cent or less and should be adjusted if 15 per cent is exceeded. Overspeed tests should be conducted with some degree of caution on account of the rather narrow margin of safety and the rapidity with which acceleration sometimes occurs. Unless the operator has had considerable experience on such work, it should not be attempted without a tachometer being in constant use. Unfortunately, manufacturers in many cases do not provide any convenient means for conducting an overspeed test, but the engineer usually has his choice of several methods of obtaining the desired speed. The safest is to increase the tension on the main spring of the flyball governor until a setting is obtained that gives the desired speed. Once obtained, the position of the adjusting nuts may be marked for future reference. The method is at best inconvenient, and some trouble may be experienced in returning to the exact speed obtained before changing the governor adjustment. A more convenient, and perhaps the best method, is to disconnect the governor valve from its operating levers, secure it in the open position and regulate the speed by the throttle. On account of the possibility of rapid acceleration considerable care is necessary in manipulating the throttle. Time may be saved in some cases by blocking the valve, or rather some one of its operating levers, so that it cannot be closed by the governor; this, however, is likely to throw excessive or undesirable strains on some parts of the mechanism, and one should be fairly certain that no ill effects will follow before attempting this. In some cases the best and easiest method is to apply sufficient pressure, either by hand or by the use of an improvised lever, to some part of the governor mechanism to produce the desired speed. In this case also one must be sure that the necessary pressure is not sufficient to damage any of the parts; but there is generally less fear of this than by the previous method, and there is rather less danger of accidentally obtaining an excessive speed.

H. M. PHILLIPS.

Washington, D. C.

Tool for Extracting Economizer Tubes

Having used a wedge type of economizer tube extractor, which caught the tube only at one point, and necessitated the turning of the extractor to different points before the tube became loosened in the header,



IMPROVED TYPE OF ECONOMIZER TUBE EXTRACTOR

I had a device made as shown in the illustration. This caught the tube practically all around.

The rod *A* is first passed through the tube, with the two halves *BB*, until the shoulder drops below the end of the tube. Next, the pipe *C*, which is tapered at the end, is inserted, thereby spreading the two halves *BB* apart. The yoke *D* is then slipped over the rod *A*, and finally the nut *E* is screwed on the rod. The threads on rod *A* are made square, to lessen the chance of stripping them. It will be clearly seen that with this type of tube puller the strain is exerted practically all around the tube.

F. J. GENTNER.

Passaic, N. J.

COMMENTS FROM READERS

Preheating Air to Boiler Furnaces

Mr. Prat's article in the Feb. 28 issue, quoting tests of a boiler with and without air heating, makes a favorable showing in a comparison of the boiler efficiencies obtained, but a closer analysis of the figures would seem to show that there were other influences favoring the test with the air heater, besides the higher temperature of the air for combustion.

From an analysis of a large number of tests on which the ultimate analysis of the coal was known and for which heat balances were obtained, it was found that the heat carried away by the flue gases representing the direct products of combustion of the coal, carbon dioxide, water vapor, and the accompanying nitrogen, was about 2.06 per cent of the heating value of the coal for each hundred degrees Fahrenheit, by which the flue gas exceeded the entering air temperature, and likewise for 100 per cent excess air the loss was 1.70 per cent per hundred degrees. Assuming the other losses such as latent heat of moisture, ashpit and unburned gases, to be the same for the two tests, we may write the heat balances as follows:

Test No.	1	2
Air heater used	Yes	No
Flue-gas temperature, deg. F.	589	572
Temperature of air to furnace, deg. F.	194	77
Difference in temperature, deg. F.	395	495
Temperature of gases leaving heater, deg. F.	450	.....
Temperature of air entering heater, deg. F.	56	.....
Fall in temperature of flue gas in heater	139	.....
Rise in temperature of air in heater	138	.....
Flue-gas analysis: carbon dioxide (CO_2), per cent	10.0	7.87
Oxygen (O_2), per cent	8.0	9.37
Nitrogen (N_2), per cent	82.0	82.76
Excess air, per cent	58	75
Heat available in steam (boiler efficiency), per cent	69.2	60.2
Loss due to latent heat of hydrogen, per cent	2.3	2.3
Loss in products of combustion, per cent	8.2	10.4
Loss in excess air, per cent	3.9	6.3
Loss in unburned carbon monoxide, per cent	0.0	0.0
Loss in unburned carbon in ashpit, per cent	3.0	3.0
Loss in radiation and unaccounted for, per cent	13.4	17.8
	100.0	100.0

If conditions on the two tests were similar, the radiation losses should be nearly the same, but as there is a large difference to the disadvantage of Test No. 2, it seems reasonable to suppose that this was due to an excessive ashpit loss, as the carbon dioxide is too low to make a material amount of carbon monoxide likely. Any advantage of this nature cannot justly be credited to an air heater or other auxiliary apparatus. It will be noted that the difference in boiler efficiency of Test No. 1 over No. 2 is 9 per cent, the difference in radiation, and the accounted loss of No. 2 over No. 1 is 4.4, leaving a net advantage of 4.6 per cent, which checks closely with the amount of heat abstracted from the flue gases to cool them 139 deg. F., which amounts to 4.3 per cent.

On the whole, water economizers would seem to offer greater advantages in the way of heat absorption and maintenance, as any form of heat-transfer surface involving close packing to obtain large area in small volume would be difficult to keep clean and prevent corrosion due to moisture entering when the boiler was out of service.

It is also likely that even this amount of preheating would cause sufficient clinkering to be troublesome in coals that are now being burned satisfactorily.

New Haven, Conn. H. D. FISHER.

Adjusting Crankpin Boxes

In the article on the adjustment of crankpin boxes in the March 14 issue, Mr. Dixon omits a few points that go along with accuracy or adjustment.

As few crankpins are perfectly round, it makes a difference what position the crank is in when the adjustment is made. In the opinion of the writer, when adjusting reciprocating engines, the crank should be about 10 deg. ahead of dead center, while on air or ammonia compressors the best position at which to make adjustments is 12 deg. past dead center. Also in backing off one-sixth of a turn on the wedge bolt, the pitch of the thread would have to be taken into account.

St. Louis, Mo. M. H. MILLS.

Compressed-Air Tank Explosions

Another phase of air-receiver explosions appears in the recent disaster at Kansas City, as reported in the March 21 issue. This explosion occurred eight minutes after starting in the morning when everything was no doubt well cooled down from the previous day's run. I am of the opinion that at the close of the run the preceding day the oily surface and oil deposit in the tank were sufficiently heated to give off a gaseous vapor as the pressure lowered during the time the compressor was shut down. When the compressor was again started and the mixture of air and gas reached a certain point under favorable compression, it was ignited either by compression or possibly by a spark originating in the mechanical operation of the compressor valve.

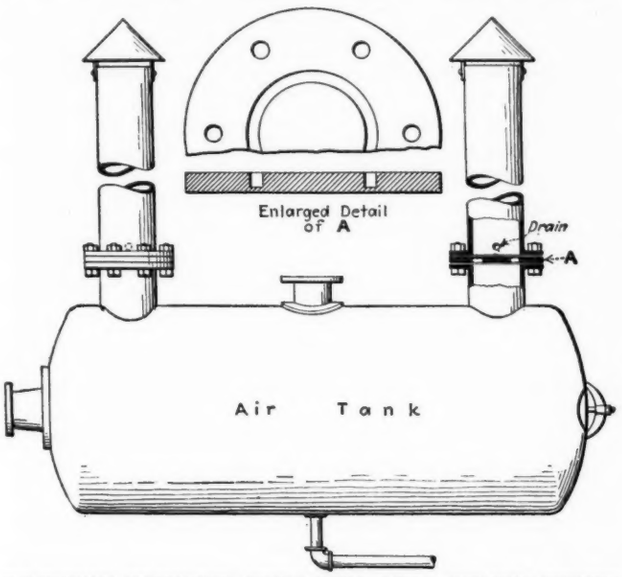
Safety pop valves on air tanks serve no purpose against explosions, except from overpressure of air discharged by the compressor in case the unloader fails.

The air explosions I have investigated revealed the fact that these occurred after a heavy demand for air, and the receiver or pipes had become heated to a high temperature. So long as a large volume of air is passing from the tank, the gas generated from oils does not become sufficient to cause an explosive mixture, but

when the demand for air decreases to a small amount, the heated oil vapor accumulates and forms an explosive mixture.

This is likely to happen after a compressor has been stopped for a short interval and again started without opening the blowoff and allowing the air to blow for a short time before building up pressure.

As one means of preventing loss of life and property in the event of an explosion, I would suggest the use of



RECEIVER EQUIPPED WITH TWO 8-IN. OUTLETS FITTED WITH SAFETY FLANGES

the old-time safety patch that was employed by steam boiler makers before safety valves came into use—this safety patch to be designed to give way at a pressure 50 per cent above the normal pressure carried and to bear an inspection stamp and to conform to the A. S. M. E. code, and the details of this flange to be worked out by the A. S. M. E. for tanks and pipe lines of certain size and specifications.

A detail of this flange, and a tank arranged for two 8-in. outlets with the safety flange placed between the flanged joints is shown in the illustration. The tops of the pipes are fitted with covers for weather protection and provided with a drain at the lowest point.

No doubt a frequent cause of the trouble is the quality of the oil used for lubrication. I know of compressors running with a very high grade of oil for the air-cylinder lubrication, but with light gaseous oils in their crankcase splash system, which is carried by the piston rod into the compressor cylinder and on into the system. I know of a very bad explosion of one of these machines, but the inspector who analyzed the oil used in the lubrication of the air cylinder found it suitable for the purpose and the cause of the explosion was considered a mystery.

From experience with this class of equipment, I offer the following precautionary measures:

1. Use proper oil for air-cylinder and splash lubrication.
2. Keep water jackets and coolers as clean and cool as possible.
3. Keep unloaders and pop valves in good order.
4. Before starting the compressor, open the blowoff valve and allow all the air to blow out of the tank before building up the pressure.
5. If service has been heavy and the tank and pipes are hot and the demand for air ceases, open blowoff and circulate air carrying out hot oil vapor.
6. Clean tanks often.
7. Do not use kerosene, gasoline or other gaseous oils for cleaning valves, etc.
8. Provide a pop safety valve of the proper size between the compressor cylinder and any other valve.
9. Bear in mind that compressors and tanks will explode.

CHARLES B. RISLEY.

Evansville, Ind.

Compensating Pressure Gages for Error Due to Water Column

It appears that my article in the Dec. 27, 1921, issue on compensating pressure gages for error due to water column has stirred up considerable discussion. So far Mr. Graham, whose article appears in the March 21 issue, has been the only one to discover the merits in my scheme.

There is a correction, however, to be made in Fig. 2. The open vent shown at the top of the loop should be replaced with a pet-cock so that the vent can be regulated as desired. The connection shown in Fig. 1 and Fig. 2 might be used for any steam pressure where it is practical to connect to a trap.

If the runs of pipe are long, they should be covered to prevent radiation that would condense the steam and lower the pressure at the gage; the pipe should also be of sufficient size to make the drop in pressure due to friction negligible.

Gages are on the market that are compensated for the head or location in which they are to be placed; for instance, indicating the depth in feet of water in a tank on the roof, the pressure from the bottom of the tank to

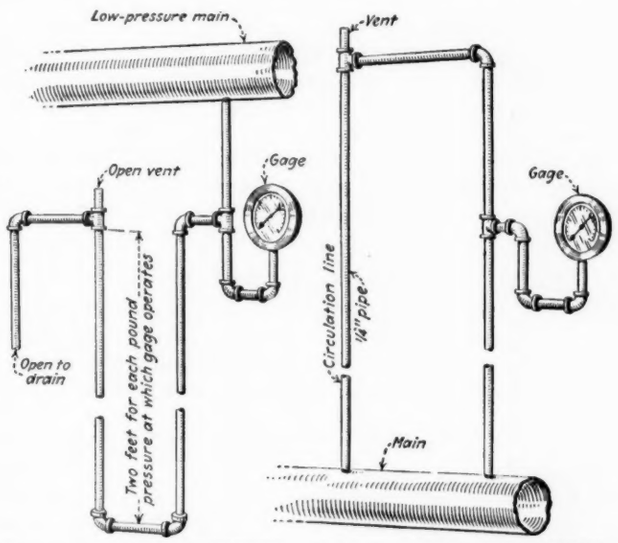


FIG. 1. GAGE CONNECTED BELOW LOW-PRESSURE MAIN

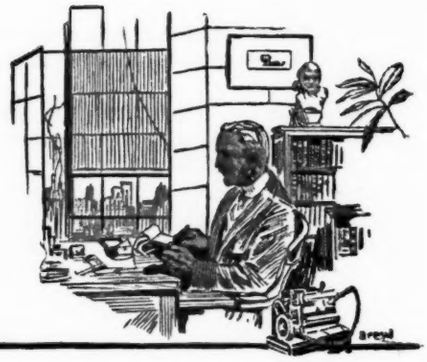
FIG. 2. GAGE CONNECTED ABOVE LOW-PRESSURE MAIN

the location of the gage is taken up by a compensating device in the gage. Steam gages for power-plant service are also made with this feature. They read only a few pounds above or below the normal pressure carried. This gives a large movement to the pointer for a small change in pressure.

W. T. MEINZER.

Brooklyn, N. Y.

QUESTIONS AND ANSWERS



Effect of Elevation on Horsepower of Gas Engine

How does the altitude of the place where a gas engine is used effect the horsepower of the engine?

R. W.

The power of a gas engine varies with the atmospheric pressure and consequently with change in elevation. If b = barometric pressure at sea level, e = barometric pressure at the elevation where the engine is used, hp = the horsepower at sea level, and hp_e = the horsepower at the elevation, then

$$hp_e = \frac{e}{b}\, hp.$$

Hard and Soft Boiler Patches

What is the difference between a hard patch and a soft patch for a boiler? R. G. N.

The hard patch consists of a piece of steel plate accurately shaped and permanently riveted to replace a portion of a boiler shell that has been removed on account of the plate having become cracked or bulged. The term soft patch usually is employed to designate a patch held on the outside of the boiler sheet by a patch bolt, which is a screw bolt with a countersunk head with square knob that may be cut off when the bolt is screwed home. Soft patches are often applied temporarily or in case of emergency and are not supposed to constitute a first-class permanent repair. Soft patches usually are made of soft iron or steel plate fitted to place by hammering cold and set in boilermaker's putty or with lead gaskets to prevent leakage and screwed in place by patch bolts screwed into tapped holes in the boiler plate.

Steam Required for Heating Water

How much steam at 90 lb. pressure would be required to heat 5,000 lb. of water from 70 to 150 deg. F. in 15 minutes where the water is contained in an open wooden tank and the steam is discharged directly into the water? J. L.

A pound of steam at the pressure of 90 lb. gage, or 105 lb. per sq.in. absolute, contains 1,187.2 B.t.u. above 32 deg. F., and when condensed and cooled to the temperature of 150 deg. F., each pound would liberate 1,187.2 + 32 − 150 = 1,069.2 B.t.u. To raise the temperature of 5,000 lb. of water from 70 to 150 deg. F. would require transfer of 5,000 × (150 − 70) = 400,000 B.t.u., and heating the water would require 400,000 ÷ 1.069.2 = 347 lb. of steam. There would be loss of heat from radiation, depending on the proportions of the tank, depth of water, room temperature, and length of time required to perform the heating according to the rate of flow of the steam. If the water is contained in a wooden stave tank, with the depth of water about one-half of the tank diameter, the loss of heat during the heating would be between 1 and 2 per cent, requiring about 380 lb. of steam at 90 lb. gage pressure, which could be discharged in 15 minutes through a short nozzle or orifice about ⅝ in. in diameter.

Interpolation from Steam Tables

Tables of properties of superheated steam usually give the total heat per pound, advancing by 10 deg. of superheat. How are values determined for intermediate conditions? S. M. F.

Values for intermediate conditions are derived by interpolation. For example, if the pressure is 100 lb. gage, or 115 lb. per sq.in. absolute, and the actual temperature of the steam is 432 deg. F., then as the temperature of dry superheated steam at the stated pressure is 338.1 deg. F., there would be 432 − 338.1 = 93.9 degrees of superheat. The total heat per pound (weight) of steam given in the tables for 115 lb. per sq.in. absolute and 90 deg. of superheat is 1,237.9 B.t.u., and for 100 deg. of superheat is 1,243.1 B.t.u. Hence per degree rise of temperature between 90 and 100 deg. of superheat there is an increase of (1,243.1 − 1,237.9) ÷ 10 = 0.52 B.t.u. As the actual number of degrees of superheat is 93.9, or 3.9 more than 90, then by interpolation the total heat per pound for 93.9 deg. superheat would be 1,237.9 + (3.9 × 0.52) = 1,239.9 B.t.u.

Boiler Efficiency

What is meant by the efficiency of a boiler? R. N. H.

The general definition of the efficiency of an apparatus, machine or appliance is the ratio of the output to the input. What is ordinarily called the efficiency of a boiler is, in reality, the combined efficiency of the boiler, furnace and grate, and is the heat absorbed in the generation of steam per pound of fuel fired divided by the heat of perfect combustion per pound of the fuel. The value obtained will be the same whether the efficiency is based on dry fuel or on the fuel as fired.

The heat absorbed by the boiler is derived from the combustible portion of the fuel actually burned, irrespective of what fraction of the total combustible fired this may be. All the fuel cannot be burned, as some of it falls through the grates and it is unfair to charge such losses to the boiler. This has led to a second efficiency, which is called "efficiency of boiler alone" as distinguished from the combined efficiency of boiler and grate, and is expressed as heat absorbed by the boiler per pound of fuel divided by the heat actually developed in the furnace per pound of fuel. The furnace is not

entirely eliminated from this consideration, as the efficiency is lowered by excess air and the amount of excess air depends on the design and operation of the furnace. On account of the difficulty of arriving at the efficiency of the boiler alone, in usual practice the combined efficiency of boiler, furnace and grate is used. The only way that the influence of the furnace and grate can be allowed for is to assume a minimum CO_2 and maximum CO with due allowance for the amount of combustible that is contained in the ash and that which may be swept away with the flue gases.

Explosion Temperature in Internal-Combustion Engine

What is the highest temperature attained in the cylinder of an internal-combustion engine at the time of explosion? J. J. L.

The maximum temperature that occurs in an internal-combustion engine at the time of explosion varies with the compression that is carried in the engine and also with the amount of fuel added. Since in an Otto engine the amount of fuel added is limited by the amount of air that is taken in on the suction stroke and also by the permissible maximum pressure at explosion, the temperature will have a range of from 2,500 to 3,500 deg. F. In the ordinary gas engine, carrying from 80 to 90 lb. compression, the maximum temperature will be in the neighborhood of 2,700 deg. F. On the other hand, with oil engines where the compression pressure is carried much higher, the maximum temperature often is as high as 3,500 to 3,600 deg. F. Theoretically, the temperature should reach about 4,500 deg. F., figuring the amount that is normally added to the air charge. However, there is a very rapid radiation of heat during the period of combustion, and this serves to keep the temperature much below the theoretical value.

Locating and Using Tram Marks for D Valve Setting

How can marks be located for using a tram to test the valve setting, or for setting the valve of a D slide-valve engine without removing the steam-chest cover? G. N. M.

To locate such marks and be enabled to set the valve without removing the steam-chest cover, it is first necessary to set the valve properly while the steam-chest

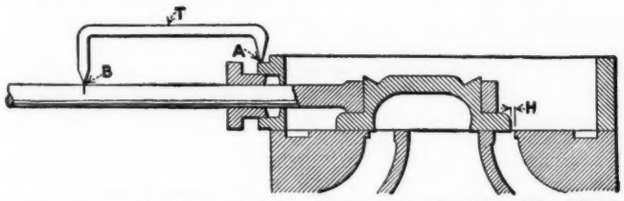


FIG. 1. TRAMMING WITH ENGINE ON HEAD-END DEAD CENTER

cover is off, and then make reference marks on the valve stem and steam chest. Preparatory to setting the valves, prepare a tram *T*, Figs. 1 and 2, with both ends pointed. This tram should be about half the length of the valve stem.

Remove the steam chest cover and set the valve with equal leads. For this purpose set the engine on the head-end dead center and measure the lead *H*, Fig. 1, which the valve has on that end; or if the valve covers the port, giving negative lead, mark the position of the valve and turn the engine forward until the edge of the valve is in line with the edge of the port, and measure the distance which the port was overlapped by the valve. Turn the engine forward until the crank-end dead center is reached and measure the lead *C*, Fig. 2, in the same manner.

If the leads are found unequal, they must first be made equal by changing the length of the valve rod. To do this, take half of the difference between the leads

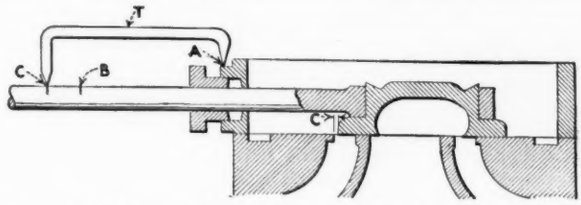


FIG. 2. TRAMMING WITH ENGINE ON CRANK-END DEAD CENTER

and change the length of the valve rod, lengthening the rod if the head-end lead is larger or shortening it if the crank-end lead is larger. If the leads are thus made equal but not of the required amount, move the eccentric forward to give more lead or backward to give less lead, as required.

After the valve has been set by measurement as above, if possible the engine should be run and indicator diagrams taken, as by that means it may be known whether the valve has been set properly, and any slight adjustment that may be necessary may be made after inspection of the diagrams. After the valve is properly adjusted, place the engine on the head-end dead center, bringing the valve to the position shown in Fig. 1 and make a punch mark on the steam chest as at *A*. Place one end of the tram in this mark and make a mark *B* on the valve stem with the other end of the tram and make the mark permanent by a punch mark. Then turn the engine to the crank-end dead center, bringing the valve to the position shown by Fig. 2 and with one end of the tram in the punch mark *A* previously made on the steam chest, scribe another mark *C* on the valve stem and make it permanent by a punch mark.

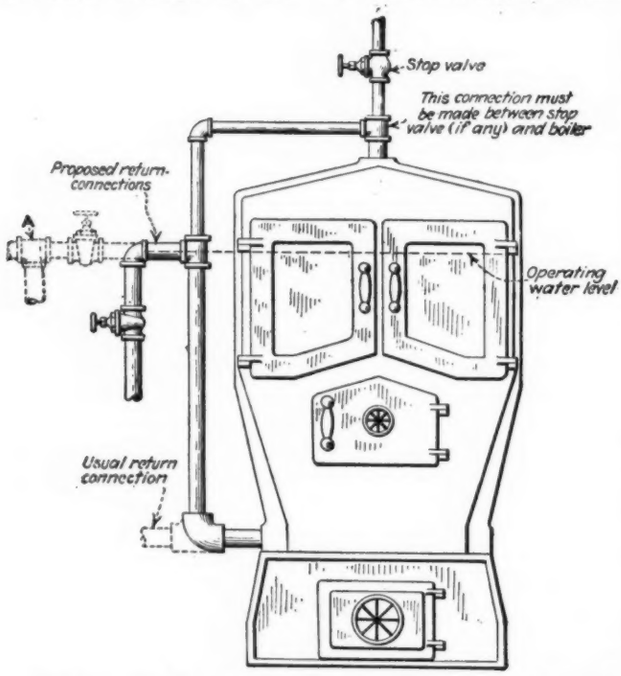
If nothing occurs but slipping of the eccentric, the valve may now be set at any time without removing the steam-chest cover by placing the engine on a center and turning the eccentric on the shaft until the tram reaches from the mark on the valve chest to the mark on the valve stem which corresponds with the dead center. But to check against a change of the length of the eccentric rod or valve stem, a test by tramming should also be made with the engine placed on the other center. Then if the mark does not agree with the tram, one-half of the correction should be made by resetting the eccentric and one-half by adjusting the length of the valve stem, and tests and adjustments should be made with the engine on alternate dead centers, each time taking out one-half of the error by moving the eccentric and one-half by adjusting the length of the valve stem, until the correct tramming is obtained for each dead center.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—Editor.]

Water Returns to Steam Heating Boilers*

WHEN the insurance of heating boilers was first begun, coverage against explosion was the only class of insurance sought. Owing, however, to the cracking of parts which was often experienced with cast-iron boilers, the insuring companies soon found that there was a market for insurance that would cover against this class of accident.

Reliable central-station power is now available in so many sections of the country that low-pressure boilers to be used for heating only will replace many of the power boilers now in use. It is also likely that the average size of boiler used for this purpose will increase, and insuring against cracking of parts has demonstrated that the larger the boiler the larger the loss. It is therefore important that


Stop valve
This connection must be made between stop valve (if any) and boiler
Proposed return connections
Operating water level
Usual return connection

CHANGE OF WATER CONNECTION PREVENTS WATER FALLING BELOW SAFE LEVEL

every possible precaution be taken to prevent the existence of conditions that are likely to lead to the cracking of the parts of boilers.

One of the most prolific causes of cracking of the parts of low-pressure steam-heating cast-iron boilers is an improper water level in the boiler. In fact, one of the most important of the many problems confronting the heating engineer in the installation of a low-pressure steam-heating system is the maintenance of a proper water level in the boilers used on the system.

If the condition of uniform pressure on the surface of the water in a steam-heating system could be maintained, no difficulty would be experienced in keeping a safe water level in steam-heating boilers using gravity returns.

Unfortunately, many conditions arise in practice that tend to prevent such uniformity in pressure. The greater the volume of steam to be moved from one point to another through a pipe or system of pipes in a given time, the greater the difference in pressure required at the two points considered. In a gravity return system the means used to compensate for the difference in pressure required at the steam outlet of the boiler and in the return pipe near the boiler is a head of water supplying a pressure sufficiently in excess of this difference in steam pressure to cause the condensation to flow to the boiler. As long as the volume of water required for this head is such that it may be safely withdrawn from the boiler, without seriously lowering the water level in it, the system will work satisfactorily.

Application of Check Valves

In practice systems are often encountered of such proportions and arrangement that the requirements for proper operation, as previously stated, are not met when first starting with a cold system. Later, however, when the volume of steam demanded is less and therefore the pressure differences required are less, the proper working conditions may be maintained. In such cases a check valve installed in the return line near the boiler may make the installation workable.

The application of check valves on a low-pressure steam-heating system in the case of two or more boilers is not nearly so satisfactory an arrangement as in the case of a single boiler. If a check valve is applied to the individual return pipe to each boiler, there is a tendency to disturb the uniformity in water levels in the boilers, since it is impracticable to have the different check valves work in unison. If a single check valve in the return main is applied, then a surging of water between the boilers is likely to occur with variations in the rate of evaporation in the boilers. Also, with this class of return connection, if, through error or otherwise, the steam stop valve from one boiler should be closed before the water return valve, while the boiler is steaming, the water would be driven from this boiler over to the others, resulting in overheating or cracking the parts.

Returns Connected at Water Level in Place of Check Valves

On account of the difficulties pointed out when check valves are used, the National Boiler and Radiator Manufacturers Association, in conjunction with the Steam Boiler and Flywheel Service Bureau, conducted a series of tests in 1920 to determine the practicability of a suggested water-level connection for the returns to steam-heating boilers.

It is evident that if the return connection to a boiler should be located at the normal water level instead of near the bottom of the boiler, as is now customary, it would be impossible to force water out of the boiler through the return pipe below the point where the connection was made to the boiler. Therefore, if the return connections were made as described, check valves on the return lines would not be required to maintain a safe water level in the boiler. While the water in a single boiler might tend to flow back into the return pipe, or in the case of two or more boilers the water might tend to surge from one boiler to another with connections as described, this action would automatically cease when the water level reached the point where the return connection was made.

If a pipe connects the steam space of a boiler with the point where the return connection is usually made, in effect this pipe becomes a part of the boiler the same as adding a section to a sectional boiler. The return connections can be attached to this pipe at a height corresponding to the safe working water level in the boiler and thereby secure the same result as would be obtained by delivering the water directly to the boiler at the water line, although it is actually introduced at the usual bottom connection.

This kind of connection gives an additional safeguard, aside from preventing the water backing out of a boiler, in that should the stop valve in the steam outlet be closed while the boiler was steaming, the boiler would still be connected to the system through the return connections. While this arrangement of piping is not intended to obviate the need for proper safety-valve protection, it would tend to prevent the accumulation of a dangerous pressure with an inadequate or inoperative safety valve, which would not be the case with a check valve on the return pipe.

The illustration shows how this method of connecting returns may be applied to a single boiler, to two or more boilers. The full line connection shows the method for

*Abstract of the report of the Steam Boiler and Flywheel Service Bureau.

one boiler, the dotted connection at *A* for two boilers. The steam connection for the equalizing pipe is shown connected to the steam outlet pipe. The upper end of the equalizing pipe could be connected to the steam manifold or drum, or to the steam space of the boiler, but in any event there must be no valves on this equalizer connection that could shut it off from either the steam space or water space of the boiler. The advice in regard to making the upper portion of the equalizing connection short and of certain minimum proportions was the result of the tests made by the National Boiler and Radiator Manufacturers Association previously referred to. It was demonstrated by these tests that when the outlet steam valve was closed with the boiler delivering a large amount of steam, which was forced out through the return connection, unless the upper portion of the equalizing connection was as direct as practicable and of ample size, the frictional resistance to the passage of the steam through this connection would be too great. These equalizing connections should be as short as practicable, using as few turns as possible. The size should not be smaller than shown in the table.

Grate Area	Size of Pipe
Four sq.ft. or less	1½ in.
Four to 15 sq.ft.	2½ in.
Fifteen sq.ft. or more	4 in.

The Engineer's Conference, of the Steam Boiler and Flywheel Service Bureau, which is composed of the engineering heads of all the companies doing a boiler insurance business, strongly advise the adoption of such connections for low-pressure steam heating boilers.

Boiler and Pipe Covering Tests

Interesting tests on pipe covering have recently been carried out at the Victoria University, Manchester, England, on behalf of the firm of Messrs. Sutcliffe Bros. & Bryce, Ltd., Globe Works, Godley, near Manchester. Test *A* was with a No. 1 asbestos mixture made to withstand superheated steam to 600 deg. F. The detailed results are as follows:

Mean thickness of covering	1.50 in.
Water condensed per square foot of external surface of bare pipe per hour	0.805 lb.
Water condensed per square foot of external surface of covered pipe per hour	0.107 lb.
Efficiency	87 per cent
Pressure of saturated steam used	50 lb. per sq.in.
Temperature of saturated steam used	298 deg. F.
Temperature of air	51 deg. F.
Temperature difference	247 deg. F.

Test *B* was a No. 4 Telluric composition intended only for low-pressure purposes and not for superheated steam, being specially applicable to boiler-feed pipe, exhaust-steam pipes and for covering a thin 85 per cent magnesia covering so as to give mechanical strength. The efficiency is high, being, as before, 87 per cent.

Mean thickness of covering	1.56 in.
Water condensed per square foot of external surface of bare pipe per hour	0.805 lb.
Water condensed per square foot of external surface of covered pipe per hour	0.107 lb.
Efficiency	87 per cent
Pressure of saturated steam used	50 lb. per sq.in.
Temperature of saturated steam used	298 deg. F.
Temperature of air	51 deg. F.
Temperature difference	247 deg. F.

Test *C* was carried out with a new product of the firm, called "Caloperite," combined with 85 per cent magnesia, in connection with the contract for a new power station at Edinburgh. The specification for the boiler and pipe covering stipulates that with steam at 700 deg. F. and a room temperature of 70 deg. the total heat loss per superficial square foot per hour must not exceed 115 B.t.u. The test shows that this figure has been obtained, being 111 B.t.u.

Maker's description of nature of covering material,	"Caloperite" and "crown" 85 per cent magnesia
Mean thickness of covering	3.9 in.
Inside diameter of pipe	9.9 in.
Temperature of steam in pipe	700 deg. F.
Temperature of atmosphere	70 deg. F.
Heat lost in B.t.u. per square foot of external surface of covering per hour	111 B.t.u. per sq.ft.

Test *D*—It is found by experience in Great Britian that magnesia will not stand over 700 deg. F., as at this temperature it begins to calcine and ceases to act as a non-conductor.

Messrs. Sutcliffe Bros. & Bryce, Ltd., have devised a new non-conducting material which they have termed "Caloperite." The Edinburgh specification states that the non-conducting material must not char at 700 deg. F., and the University of Manchester Tests were carried out under the severe conditions of 1,000 deg. F., with complete success. It is intended to use the "Caloperite" composition only next to the pipe to take the first shock of the heat, and then to finish off with 85 per cent magnesia. The University report states:

The insulating material was applied to a 5-ft. length of steam pipe, closed at each end by a flange. The pipe was heated internally to a temperature of 1,000 deg. F. and maintained at that temperature for 12 hr. On cutting out a section of the covering, the surface which had been in contact with the hot pipe showed no effect of charring or disintegration.

Hydro-Electric Unit Wrecked at Niagara Falls

About 3 a.m., April 20, a serious accident occurred in the plant of the Ontario Power Co., of Niagara Falls, which is part of the system of the Hydro-Electric Power Commission of Ontario. In this plant there are installed 16 units having an aggregate capacity of 200,000 hp. It is reported that four 16,000-hp. and two 20,000-hp. units were involved in the wreck, the latter two being wrecked and

LOOKING DOWN INTO POWER HOUSE THROUGH HOLE IN THE ROOF

the other four damaged by water. When part of one of the 20,000-hp. generators was hurled through the roof, the covering over these two machines fell and caused the turbine casings to fail. The Johnson valves in the turbine's penstocks were closed as soon as possible, but in the meantime the water flooded four more machines.

As far as can be learned, the contributory cause of the mishap was a short-circuit somewhere on the line of the Hydro-Electric Power Commission. The sudden dropping of the load caused the units feeding the line to speed up. At that time four units in the power house of the Canadian Niagara Falls Power Co. rated at 10,000 hp. each, were running in parallel with the units in the Ontario Power Co.'s station. When the operator in the Canadian Niagara station saw the four units speeding, he pulled over the rheostats as far as they would go in an effort to cut down the voltage. This, however, had no effect, and when it was discovered that the units were being driven as motors by the larger generators in the Ontario Power Co.'s station, the feeder switches were pulled and the Canadian Niagara units cut off the line. Shortly afterward one of the 20,000-hp. units in the Ontario Power Co.'s station failed.

The destroyed end of the power house with its equipment was erected by the Hydro-Electric Commission of Ontario

during the war to meet the great demand for power at that time. This increased the total capacity of the station from 160,000 hp. to 200,000 hp. The waterwheels were built by S. Morgan Smith Co., the generators by the Canadian General Electric Co.

It is also reported that a few days prior to the accident one of the large units in the Chippawa-Queenston station, rated at 55,000 hp., was damaged by one of the fan blades attached to the generator for ventilating purposes coming off and wedging between the rotor and the windings, which necessitated shutting down this machine for repairs. A third 55,000-hp. unit is being erected at Queenston, and it is expected to have this machine in operation by July. The power houses of the Toronto Power Co. and the Canadian Niagara Falls Power Co. are being operated with their gates wide open so as to supply the Hydro-Electric Power Commission of Ontario with the requisite energy. Part of the loss is also being made up from the Niagara Falls Power Co.'s American plant. Less than fifteen minutes after the accident the Canadian Niagara Falls Power Co. and the Toronto Power Co. were feeding the Hydro-Electric power system.

N. E. L. A. Annual Convention at Atlantic City, May 15-19

The forty-fifth annual convention and exhibition of the National Electric Light Association, like previous ones, will give the visitor a wide choice of subjects among the many meetings to be held each day. The program has been worked out with care, however, so as to result in the least possible interference.

While the Association gives its attention to the entire central-station field, power engineers will find a number of features on the convention program of particular interest and value to them. These features are given herewith, since the program itself is too lengthy to be printed in full and many parts deal with business and electrical transmission matters.

Monday, May 15, the first day of the convention, the big events will be two parallel, or simultaneous, sessions of the Technical National Section, of which N. A. Carle is chairman. Both sessions will be held in the afternoon. At one of them, Mr. Carle will give an address, the report of the committee on Hydraulic Power (of which Markham Cheever is chairman) will be presented and a motion picture called "Everlasting Power" will be shown. The latter was prepared by Stone & Webster to illustrate the construction of the Caribou hydro-electric development of the Great Western Power Co. in California. At the other session the report of the Committee on Safety Rules, of which Thomas Sproule is chairman, will be presented. The president's reception will follow in the evening.

Tuesday morning will be devoted to the first of four general and executive sessions. After an address of welcome by the mayor, the retiring president, Milan R. Bump, will give an address. The other speakers will include Martin J. Insull and N. A. Carle. Among the reports to be presented will be that of the Committee on Rate Research. In the afternoon there will be two parallel sessions of the technical section, at one of which the report of the Prime Movers Committee will be presented. The chairman of this committee, whose report will be greeted with particularly keen interest, is H. P. Liversidge.

Wednesday will bring an opportunity to hear Herbert Hoover speak, at the general and executive session, in the morning. In the afternoon there will be two sessions of interest—that of the Public Relations Section, at which the report of the Committee on Uniformity of State Regulatory Laws will be presented, and that of the Technical Section, at which the report of the Committee on Electrical Apparatus, of which A. H. Lawton is chairman, will be presented.

Thursday morning, at the general and executive session, W. S. Murray, lately director of the Superpower Survey, will tell about the report of the Hydro-Electric Power Commission of Ontario. In the afternoon sessions of the commercial and the technical sections will be of interest; at the former, reports will be given by the Power Sales Bureau and the Electric Power Economics Division, and power subjects in general will be discussed; while at the second, a paper will be given on the "Analysis of Economic Loss Due to Power Factor—Basic Meterable Factors." In the evening there will be a session of the Public Policy Committee, of which Sidney Z. Mitchell is chairman. The report of the committee will be presented, and an address will be made by Attorney-General Daugherty.

Friday will close the convention with a general and executive session. Among a number of reports to be presented will be those of the Committee on Water-Power Development, of which Franklin T. Griffith is chairman, and of the Committee on Electrical Resources of the Nation, of which M. S. Sloan is chairman. Final business affairs will be carried out, including the formalities of the election and installation of the new officers.

Other features of the convention will be: The exhibitions, which were omitted at the last two conventions and are now restored; four motion pictures (to be shown Tuesday and Wednesday evenings); the *Convention Daily*, which will be published Tuesday, Wednesday and Thursday by the *Electrical World* at its own expense; and various entertainments, including three evenings of dancing to Paul Whiteman's orchestra.

The exhibitions, meeting rooms and offices will all be on the Million-Dollar Pier. There will be no registration fee for members, but for their male guests there will be a charge of five dollars apiece. Transportation to and from the convention at fare and a half can be arranged by applying to Clarence L. Law, master of transportation. The national headquarters of the Association are in the Engineering Societies Building, at 29 West 39th St., New York City.

Sutcliffe-Speakman Process of Low-Temperature Carbonization

There has been published recently in England some particulars of the new "Sutcliffe-Speakman" process of carbonizing coal. This process depends essentially on the discovery that if coal is powdered and mixed with 20 to 25 per cent of powdered coke breeze, the mixture can be briquetted without the aid of a binder, and the briquettes can then be carbonized at any temperature without expansion, so that no special retort is necessary. This question of the expansion of coal during carbonization has been one of the most serious difficulties to overcome in the low-temperature process.

The yield obtained per ton of coal is said to be about 10,000 cu.ft. of gas, of about 550 B.t.u. per cu.ft., 20 to 25 gal. of oil and an extraordinary high yield of sulphate of ammonia, about 35-40 lb., practically the whole of the organic nitrogen in the coal being converted into ammonia. The residual fuel is of remarkable quality, almost exactly like charcoal, and lights readily. The cost of washing, drying, grinding and briquetting the coal for a 100-ton plant in 24 hours is stated to be only about 5 shillings per ton.

It is often difficult to put safety guards around belting in such a way as to protect those working nearby and yet not interfere with maintenance or cost too much. The National Safety Council, with offices at 168 North Michigan Ave., Chicago, has made a study of this and many other safety problems, and keeps on file helpful information on this matter, including photographs and specifications.

Reduction of more than 31 per cent in the number of accidents per 100,000 of population was achieved in California between 1914 and 1920, according to figures of the State Industrial Accident Commission, as reported in the *National Safety News*. The number of fatal accidents in 1920 was about 17 in 100,000 of population.

For the development of hydroelectric plants in Jugoslavia, a syndicate has been formed in that country to study the water powers of the Bosna and the Drina Rivers. It is planned to build an 8,000-hp. station near Modric and a 20,000-hp. plant on the lower Drina.

News in the Field of Power

Water Works Engineers to Gather in Philadelphia, May 15-19

The American Water Works Association is to hold its forty-second annual convention May 15-19 in Philadelphia, Pa., with headquarters at the Bellevue-Stratford Hotel. A full program has been arranged, covering exhibits of manufacturers' equipment, reports of special committees, many technical papers, social and outing diversions and topical discussions. The program, of course, will deal entirely with water-works problems, but several features of it, which apply particularly to the power plant, are as follows:

An informal discussion of engines, boilers and similar equipment of the pumping station, to be held Monday morning, the first day;

Motion pictures showing high-pressure steam being discharged to the atmosphere and shut off in 30 sec. by Dean control, with description by Peter Payne Dean, to be given at 8 o'clock Tuesday evening;

A session on pipe for Wednesday evening, at 8 o'clock, with the following papers: "Some Observations Concerning Wood Pipe," by J. W. Ledoux; "Report of Committee on Standard Specifications for Cast Iron Pipe and Specials," by F. A. Barbour, chairman; "Experience with Cast Iron Water Pipe for Pressures Higher than Allowed by Current Specifications," by C. E. Inman; "Centrifugally Cast Iron Pipe," by Peter Gillespie;

Another evening session, for Thursday, at which papers will be given on: "Purification of Water for Industrial Purposes," by S. T. Powell; "Lime, Soda and Zeolite Water Softening," by A. S. Behrman; "Turbo-Centrifugal Pumps," by Richard Waller.

The secretary of the Association is J. M. Diven, 153 West 71st St., New York, N. Y.

To Make Trent Process Fuel

It is reported that Joseph P. Tumulty, of New Jersey, formerly secretary to President Wilson, and Raymond T. Baker, of Nevada, formerly Director of the Mint, are forming a corporation to manufacture a processed coal under the Trent process at the old plant of the Virginia Shipbuilding Corporation at Alexandria. Mr. Tumulty will be vice-president and attorney for the firm, which, it is reported, has already leased the old plant.

The Trent process consists in powdering a poor quality of coal and mixing it with oil and water. The combustible part of the coal has an affinity for the oil, and forms an amalgam with it. The ash separates out and stays in the water. The result is a high-quality fuel that may be burned as such or first distilled for recovery of the oil.

Bituminous Demand, Production and Prices Increase

The demand for bituminous coal, after remaining surprisingly low in the first few weeks of the strike, increased sharply in the last week of April, and production increased to meet it. Estimates of the Geological Survey placed the production for the week ended April 29 at over 4,000,000 tons of bituminous, as compared with 3,560,000 tons for the previous week.

In spite of the increased demand, it is felt that most consumers are still holding off as long as possible in the hope of lower freight rates.

The tendency in prices has also been upward, the *Coal Age* index of bituminous spot prices having gone up 15 points, from 206 on April 24 to 221 on May 1.

The attitude of the Government, at this writing, remains one of watchful waiting. Reports of Federal intervention have been somewhat exaggerated. The House Committee on Labor, however, is reported as being favorably inclined toward the second Bland bill, providing for a fact-finding agency of ten members.

Colorado River Development Bills Not Likely To Be Pushed Now

No rapid legislative progress is anticipated for the Johnson and Swing bills, which proposed plans for flood control on the Colorado River and for the utilization of the waters of the stream. Congress and the Administration are participating in the systematic study of the Colorado River situation being made by the Colorado River Commission. Until this Commission submits its recommendation, it is improbable that serious attention will be given any legislation prescribing methods for solving those problems.

Some time necessarily must pass before the Colorado River Commission, on which each of the states in the river's basin is represented, will be in a position to submit recommendations. A number of hearings have been held, but it is intended to have further public discussion of the matter. Other hearings are scheduled to begin August 1.

Since there are such differences of opinion among the states concerned as to the best methods of utilizing the resources of the river, considerable time must elapse after the hearings before the Commission can be expected to submit concrete recommendations. Once these recommendations are submitted, it is safe to say that they will be translated immediately into legislation. Even then progress will be slow, because of the complexity of the problems and the large amount of money that is involved.

Potomac Electric Valuation To Go to U. S. Supreme Court

The Public Utilities Commission of the District of Columbia has requested the United States Supreme Court to set for hearing at an early date in its next term, beginning in October, 1922, the Commission's appeal from the Court of Appeals of the District of Columbia against the Potomac Electric Power Co., of the District of Columbia, involving valuation of the electric company, on which hinge the rates charged the Washington public for electricity.

The case entered the courts after the commission, in fixing the fair value of the power company, reduced the rate from 10 to 8c. per kw.-hr. The company filed a suit in the Supreme Court of the District to enjoin the enforcement of the 8c. rate until the courts had finally passed on the legality of the commission's determination of fair value. The injunction was granted and the difference in the rates impounded. The commission's valuation was sustained, but this decision was reversed on appeal to the Court of Appeals of the District of Columbia, which held that the lower court had not exercised "its own independent judgment" and that the value of the power company's property increased between July 1, 1914, and Dec. 31, 1916, on account of higher prices.

Under the District Supreme Court's decision, the valuation of the company would fix the rate to consumers at 8½c. per kw.-hr. instead of 10c., and pending final outcome of the case the difference between the two rates is being impounded subject to refund to consumers if the lower rate is sustained, or to be retained by the company if the higher rate is upheld.

The Commission points out that there is now $2,500,000 impounded under this injunction and that it is embarrassed in exercising its rate-making powers pending determination of the legality of its valuations.

Alberta, Canada, to Arrange Lectures on Fuel Saving

An office that was established by the government of the Province of Alberta, Canada, in the fall of 1920, for the purpose of demonstrating and educating the public in the use of coal, has proved so successful that it is planned to extend its educational work so that owners, plant engineers and firemen may obtain information and advice on economical equipment and new devices connected with the development of power or the burning of fuel. The plan will be to get up permanent lectures with lantern slides, keeping them as free as possible of technical matter. There will be a series of them for each of the following subjects: Hand firing,

stoker firing, draft equipment, CO equipment, feed-water equipment, boilers and types of steam engines and turbines, measuring instruments, ash-handling equipment, pumps, types of furnaces, steam piping, insulation, coal-handling equipment.

G. R. Pratt, fuel engineer with The Mines Branch, Fuel Demonstration, 277 Smith St., Winnipeg, Man., reports that the government has had the co-operation of a number of American manufacturers of power-plant apparatus in the way of getting together material for the lectures, and he suggests that it would be mutually helpful for other such manufacturers to get in touch with him in the same way. He feels also that engineers and firemen have a lot of information that would be very useful in his work, and says that he would be grateful for any such material which he could pass along for the benefit of fuel conservation.

New Publications

Mechanical Stokers. By Joseph G. Worker, B. S., Secretary of the Stoker Manufacturers' Association of the U. S., member A.S.M.E., and Thomas A. Peebles, B.S., member A.S.M.E. Published 1922 by McGraw-Hill Book Co., Inc., 370 Seventh Ave., New York City. Cloth; 6 x 9 in.; 258 pages; 108 illustrations and numerous tables. Price $3.00, postpaid.

Here is a book that meets a real need. The subject of stokers is too broad to be treated with any degree of thoroughness in one or two chapters. It requires a specialized volume such as this for adequate treatment. The following general subjects are covered: Combustion, as applied to stoker work; mechanical stokers and their development; coal and coal-producing fields of the United States; combustion characteristics of coal and selection of suitable stoker equipment; draft; factors affecting selection of stoker equipment; stoker equipment of modern steam-power stations; application of stokers—determination of size; installation of stokers—specifications—contracts—guarantees—boiler-room log.

After describing (and illustrating) 28 modern stokers of different types, the book shows what stokers and furnace conditions are suited to the various American coals. The chapter "Stoker Equipment of Modern Steam-Power Stations," describing the equipment used in seventeen of the large modern stations, should be of interest to engineers who wish to study the best practice.

Personals

David J. Armour has recently joined the sales force of the John F. Robertson Co. He is intrusted with the New York and New Jersey territory.

Arthur L. Mulligren has opened offices as a consulting engineer at 555 Gates Bldg., Kansas City, Mo., and 1705 Equitable Trust Bldg., New York City. He will specialize in the design, management and appraisal of power plants and public utilities.

Peter H. Bullock, for forty-two years chief engineer of the Massachusetts Reformatory at Concord, retired from that position on May 1. He was appointed in 1880 and has served under nine different state administrations. Mr. Bullock boasts of the unique record of never having been out of employment a single day in fifty-six years.

Society Affairs

Coming Conventions

American Society of Mechanical Engineers, 29 West 39th St., New York City. Spring meeting at Atlanta, Ga., May 8-11.

American Water Works Association, 153 West 71st St., New York City. Annual convention at Philadelphia, May 15-19.

National Electric Light Association, 29 West 39th St., New York City. Annual convention at Atlantic City, N. J., May 15-20.

American Order of Steam Engineers; Andrew Lauterbach, 4726 North Warnock St., Philadelphia, Pa. Annual convention and exhibition at Philadelphia, June 5-9.

National District Heating Association; D. L. Gaskill, Greenville, Ohio. Annual convention at Cedar Point, Ohio, June 20-23.

American Society for Testing Materials, 1315 Spruce St., Philadelphia, Pa. Annual meeting at Atlantic City, N. J., June 26-July 1.

Canadian Association of Stationary Engineers; G. C. Keith, 51 Wellington St. West, Toronto, Ont. Annual convention and exhibition at Kitchener, Ontario, June 27-29.

National Association of Stationary Engineers; Fred W. Raven, 417 South Dearborn St., Chicago, Ill. Annual conventions and exhibitions of the State Associations scheduled as follows:
New Jersey, at Elizabeth, June 2-4; E. J. Flynn, 423 Newpoint Road, Elizabeth, N. J.
Illinois, at Chicago, June 7-10; I. S. Pieters, 1130 Clay St., Chicago.
New York, at New York City, June 8-10; T. J. Condon, 102 Seventh Ave., New York City.
Indiana, at Anderson, June 9-10; Frederick L. Ray, Anderson, Ind.
New England, at Springfield, Mass., July 12-14; James Morgan, 53 Devonshire St., Boston.
Michigan, at Kalamazoo, July 19-21; A. M. Adams, 1307 Stockbridge Ave., Kalamazoo, Mich.

Vancouver Section, A.I.E.E., will meet June 2 for a talk by C. R. Yuill on "Electric Power for Irrigation."

Baltimore Section, A.I.E.E., will meet May 19 for a paper on "Application of Electricity to the Steel Industry," by R. B. Gerhardt, electrical superintendent of the Bethlehem steel plant at Sparrows Point.

The Indiana State Association of the N.A.S.E. is going to boost attendance at its coming convention at Anderson, June 9-10, by awarding a one-hundred-dollar prize each day to the engineer whose registration card bears the lucky number.

The American Society of Heating and Ventilating Engineers will hold its semi-annual meeting this year in two cities, June 6-7 in Buffalo, and June 8-9 in Detroit. Headquarters in Buffalo will be the Hotel Iroquois, and in Detroit the Wolverine. The trip to Detroit will be made over night by boat.

Akron Section, A.S.M.E., will meet May 16 to hear B. A. Tozzer, of the Niles Bement Pond Co., tell about his travels through India, China and other adjacent countries.

Bloomfield Association No. 5, N.A.S.E., is the title of the new association instituted in New Jersey on April 28. There were 23 charter members. State deputy John J. Reddy officiated, W. F. Willin was elected president and P. A. Kelsey secretary. The association will meet on the first and third Friday of each month. The newly elected secretary offered a gavel and a flag, and Alfred Engel, of Jenkins Bros., promised a ballot box to the organization.

Business Items

The London Steam Turbine Co. has moved its main office and works to Troy, N. Y.

F. A. Vaughn, Inc., 326 Metropolitan Block, Milwaukee, Wis., is the new name recently adopted by the firm of Vaughn & Meyer, electrical and mechanical engineers.

The Wayne Oil Tank and Pump Co., Fort Wayne, Ind., has changed its name to the Wayne Tank and Pump Co., on account of its recent purchase of the Borromite Co. of America, which sold Borromite water-softening systems.

The Wilson-Snyder Manufacturing Co., the International Valve and Piping Co., and the Pittsburgh Supply Co. have moved their New York offices to larger quarters and are now all together in the Grand Central Terminal Bldg. at 70 East 45th St.

John L. Taylor, dealer in power and contracting equipment, iron- and woodworking machinery, has announced the removal of his business from the Bulletin Building to 211 North Third St., Philadelphia. He would be glad to hear from manufacturers with agencies open in his lines.

The Steel-Flex Coupling Corporation has been incorporated for $250,000 under the laws of Michigan, with general offices in the First National Bank Building, Detroit. It manufactures cushion flexible couplings for power transmission, which allow misalignment between shafts and absorb shocks. Contracts will be let for helical-shaped coils of rectangular steel, machine-steel parts and small to medium steel castings.

The New York State Gas and Electric Corporation, with gas and electric plants in Ithaca, Cortland, Norwich, Oneonta and Sidney, N. Y., recently elected the following officers: President, S. J. Magee; vice president, G. A. Strain; secretary-treasurer, O. E. Wasser. J. I. Mange, the former president, has resigned to give his entire time to his duties as vice president of the J. G. White Management Corporation, of New York City.

Trade Catalogs

Oil Engines—Ingersoll-Rand Co., 11 Broadway, New York City. A 20-page bulletin on the Price stationary oil engine, of the horizontal, single-cylinder, four-stroke-cycle type, built in 50 and 100-hp. sizes.

Oil Burning Appliances — Aeroil Burner Co., Inc., 266-270 Hudson Ave., Union Hill, N. J. Bulletin No. 20, describing portable heating torches, self-heating soldering irons and similar apparatus with which oil or kerosene is used for heating purposes.

Powdered Fuel Systems — Grindle Fuel Equipment Co., Harvey, Ill. Catalog No. 4, 40 pages, containing facts and figures to support the pulverized-fuel argument, and describing very clearly the various pieces of apparatus supplied by the company.

Boiler Practice for Textile Mills—Heine Boiler Co., St. Louis, Mo. Bulletin No. 51, 32 pages, consisting of advice on how to obtain economy in the production and utilization of steam in textile plants, with a large number of installation photographs in such plants.

Power and Heating Boilers—Fitzgibbons Boiler Co., Inc., 47 West 42d St., New York City, New 16-page catalog of the Fitzgibbons Boiler, which is built in sizes up to 3,500 sq.ft. of heating surface and for pressures from 150 to 100 lb. for power and 15 lb. for heating.

Fuel Saving in Gas Producers and Furnaces—The Chapman Engineering Company Division of the C. & G. Cooper Co., Mt. Vernon, Ohio. Reprints of W. B. Chapman's paper on "Fuel Saving in Modern Gas Producers and Industrial Furnaces," which was given at the annual meeting of the A.S.M.E. in December, 1921, are being distributed free of charge. Mr. Chapman has long made a study of the subject and recently spent the greater part of a year in Europe studying the best furnace practice there.

Kingsbury Thrust Bearings—Kingsbury Machine Works, 4320 Tackawanna St., Frankford, Philadelphia, Pa. Although described as "Catalog C," this 72-page booklet is more in the nature of a textbook, describing thoroughly the principles and the operation of the Kingsbury thrust bearing, which is used in large vertical generators and for similar duties.

Welding Rods and Electrodes—Page Steel and Wire Co., Bridgeport, Conn. Catalog 510, 40 pages, containing some specifications of the American Welding Society, a description of the company's rods and electrodes, interesting photographs and useful tables.

Cooling Towers—Wheeler Condenser and Engineering Co., Carteret, N. J. Catalog 109-C, 54 pages. The principles of a cooling tower are explained and a large number of interesting photographs are given, showing different kinds and sizes of towers installed.

Water Softening Apparatus—International Filter Co., First National Bank Bldg., Chicago, Ill. Bulletin J-73, 16 pages, containing prices and descriptions of the standardized sizes of International cold-process lime soda softeners, which have capacities from 250 gal. to 5,100 gal. of water per hour.

Oil Filter—Wayne Oil Tank and Pump Co., Fort Wayne, Ind. Bulletin 6600, describing briefly the new type "E" filter, which is a small continuous-flow oil purifier for handling up to 60 gal. per hour of dirty engine oil, especially adapted for individual engine oiling systems and small engine rooms.

Fuel Prices

BITUMINOUS COAL

The following table shows the trend of the spot steam market in various coals (mine-run bases, f.o.b. mines):

Coal	Market Quoting	April 24, 1922	May 1, 1922
Pool 1,	New York	$3.65	$3.50@4.00
Pocahontas,	Columbus	2.00	2.25@2.50
Clearfield,	Boston	2.70	2.50@2.75
Somerset,	Boston	2.70	2.60@3.00
Pittsburgh,	Pittsburgh	.....	.....
Kanawha,	Columbus	2.15	2.50@2.75
Hocking,	Columbus	2.15	2.75@3.00
Pittsburgh No. 8	Cleveland	2.55	2.75@3.00
Franklin, Ill.,	Chicago	2.75	2.75@3.25
Central, Ill.,	Chicago	2.65	2.60@2.85
Ind. 4th Vein,	Chicago	2.50	2.25@2.75
Standard,	St. Louis	....	2.50@3.00
West Ky.,	Louisville	2.00	2.50@2.65
Big Seam,	Birmingham	1.70	1.50@1.90
S. E. Ky.,	Louisville	2.40	2.50@3.00

New York—May 3, Port Arthur light oil 22@25 deg. Baumé 3⅜c. per gal.; 30@35 deg., 4⅜c. per gal., f.o.b. Bayonne, N. J.

Chicago—Apr. 5, for 24@28 deg. Baumé, 85@90c. per bbl.; 21@36 deg., 2⅜@2½c. per gal. in tank cars f.o.b. Oklahoma refinery, or freight adjusted.

Pittsburgh—Apr. 25, f.o.b. refinery, Pennsylvania, 36@40 deg. 4⅜c. Kentucky fuel oil, 26@30 deg., 3c. per gal. Western, 24@30 deg., 85c. per bbl.; 32@34 deg., 3c. 36@38 deg., 3¼c. 38@40 deg., 3½c. per gal.

St. Louis—Mar. 25, prices f.o.b. cars, tank lots; 24@26 deg. Baumé, 90 c. per bbl.; 26@28 deg., 95c.; 28@30 deg., $1.10; 32@34 deg. 2⅜c. per gal.

Philadelphia—May 1, 26@28 deg. Baumé, Oklahoma, 85@90c. per bbl.; 30@34 deg., Oklahola (group 3), 2⅜ @3c. per gal.; 16@20 deg. Seaboard, $1.05@$1.15 per bbl.

Cincinnati—Apr. 25, for 26@28 deg. Baumé, 4½c.; Diesel 32@36 deg., 4⅜c. per gal.; distillate 38@48 deg., 5½c.

Cleveland—Apr. 25, 26@30 deg. Baumé, 3½c. per gal.

New Plant Construction

PROPOSED WORK

Cal., San Francisco—The Pacific Gas & Electric Co., 445 Sutter St., is having plans prepared for substations at Turlock, Riverbank, O'Banion Corners and Hughson. About $75,000 each. Construction will be carried on under the supervision of the Engr. Dept. of Company.

Fla., Tampa—J. P. Hamilton is receiving bids for waterworks, including 15,000 gal. centrifugal pump, 15 hp. electric motor, 50,000 gal. tank, 100 ft. tower, cast iron pipe, etc. About $30,000.

Ill., Chicago—A. S. Alschuler, Archt., 28 East Jackson Blvd., is receiving bids for four 3 story, 158 x 350 ft. apartments including a steam heating system on Ingleside and 54th Sts., for R. A. Gore. About $600,000.

Ill., Chicago—P. Gerhardt, Archt., 64 West Randolph St., is receiving bids for a 3 story, 57 x 112 ft. furniture store including a steam heating system on 57th Ave. and 22nd St. for M. M. Davidson. About $150,000.

Ill., Chicago—Rissman & Hirschfield, Archts., 139 North Clark St., will soon receive bids for an 8 story, 62 x 150 ft. apartment including a steam heating system on Sheridan and Greenleaf Aves., for J. A. Albert and M. Bernstein, 2701 West North Ave. About $1,000,000.

Ill., Chicago—The Tennessee Illinois Phosphate Co., 716 Fisher Bldg., A. Thompson, Purch. Agt., is in the market for a boiler feed pump, 3½ in. duplex cylinder or 5 in. single cylinder.

Ill., Evanston — Perkins, Fellows & Hamilton, Archts., 10 Tower Court, Chicago, will soon receive bids for a 3 and 4 story high school including a steam heating system on Lake and Church Sts. for the Bd. Educ. About $2,500,000.

Ill., Joliet—D. H. Burnham & Co., 209 South LaSalle St., Chicago, is receiving bids for a 9 story, 49 x 120 ft. apartment hotel including a steam heating system on Western and Pine Sts. for M. Walker, 110 John St. About $400,000. Noted April 11.

Ind., Hammond—J. Erickson, Engr., 30 North La Salle St., Chicago, Ill., will receive bids until May 17 for a 1 story, 50 x 75 ft. boiler house, a 1 story, 65 x 95 ft. pumping station. About $75,000. Wolf, Sexton, Harper & Trueax, 19 West Madison St., Chicago, Archts. Noted Dec. 27.

Ind., Hammond—Jones & Laughlin Co., Ross St., Pittsburgh, plans to build a steel plant here. Probably private plans.

Ind., South Bend—The Bd. Public Wks., J. W. Trayne, Supt., plans a 2 story pumping station on Oliver St. to have capacity of 30,000,000 gal. per day. About $50,000. Architect not selected.

Ia., Dubuque—The city is having plans prepared for an air lift system of pumping from present artesian wells and drilling two additional wells, single compressor and air lift equipment. About $100,000. Mead & Seastone, Madison, Engrs.

Kan., Phillipsburg—The city will receive bids until May 15 for furnishing and laying 2 mi. 6 in. pipe, installing and constructing pump house, pump and engines complete. G. P. Taylor, Junction City, Engr.

Me., Portland—The city School Comn. will receive bids until May 17 for a 2 story, 70 x 400 ft. high school in the Deering Dist. About $500,000. T. M. James Co., 3 Park St., Boston, Archt. Noted Dec. 6.

Mass., Boston—The Bureau of Yards and Docks, Navy Dept., Wash., D. C., will receive bids until May 25 for boiler in Marine Hospital here.

Mass., Boston—The Bureau of Yards and Docks, Navy Dept., Wash., D. C., received bids for a sub-station, first aid station and distribution system from F. T. Ley & Co., 495 Main St., Springfield, Mass., $99,690; W. G. Cornell, 19 Patterson St., Wash., D. C., $101,000; Carroll Electric Co., 714 12th St., Wash., D. C., $53,490. Noted April 11. Spec. 4550.

Minn., Crosby—H. L. Nicholson, Clk., is receiving bids for furnishing deep well pump, capacity 500 gal. per min., electric motor, 3 phase, 60 cycle, 220 volt. H. I. Pearl, Engr.

Minn., St. Paul—The city will receive bids until May 22 for furnishing and erect-

ing two 250 hp. boilers at the McCarron pumping station.

Neb., Culbertson—W. J. Mohr, Clk., will receive bids until May 17 for furnishing and installing pipe line, pump machinery and reconstructing old well including one 20 hp., 220-440 volt, 3 phase, 60 cycle, 900 R.P.M. motor; one power head for 6¾ x 24 in., 2 plunger cylinder or power head for 6½ x 24 in. double acting deep well cylinder. About $15,000. Noted March 21.

Neb., Imperial—The Frenchman Valley Irrigation Dist., J. L. Kilburn, Secy., rejected bids for building Harvey Dam flume and pipe lines and setting valves and gates. About $90,000. Hershey & Merrick, Brownell Blk., Lincoln, Engrs. Noted April 11.

New Mex., Albuquerque—The city is having plans prepared for a 120 x 120 ft. reservoir, capacity 2,500,000 gal. including one 6 in. centrifugal pump. About $75,000. F. M Kimball, City Engr.

New Mex., Albuquerque—The city is having plans prepared for a 50 x 120 ft. Sewage treatment plant with 2 settling tanks, sludge bed and chlorinating chamber, including two centrifugal pumps. About $115,000. T. M. Kimball, City Engr.

N. Y., Binghamton—The Binghamton Light, Heat & Power Co., 172 Washington St., is having plans prepared for a transmission line. About $200,000. Hoadley & Giles, Phelps Blk., Engrs.

N. Y., Dunkirk—The Bd. Water Commissioners plans hydro electric water plant here. About $1,400,000.

N. Y., Rome—M. C. Spadafora, 831 East Dominick St., is in the market for complete electric driven air compressor and tank for high pressure.

N. Y., Syracuse—The Bd. Educ. plans to build a school. Cost between $750,000 and $800,000. Architect not announced.

N. C., High Point—R. K. Stewart & Son, R. K. Stewart, Purch. Agt., are in the market for a double drum Lidgerwood or Stroudsburg hoisting engine and a 25 hp. boiler, (used).

N. C., Morganton—The state, E. M. Goodwin, Supt., will receive bids until May 18 for renovation and improvement of heating plant for the North Carolina School for Deaf.

O., Cincinnati—The Cincinnati Terminal Warehouse Co., W. E. Fox, Mgr., is having preliminary plans prepared for a 7 story, 200 x 600 ft. terminal warehouse on Front St. and Central Ave., including a steam power plant. About $3,000,000. A. M. Allen & Co., Euclid-21st Bldg., Cleveland, Archts. and Engrs.

O., Cincinnati—Tietig & Lee, Archts., 901 Fourth Natl. Bank Bldg., will receive bids until May 17 for a 10 story, 80 x 100 ft. office building including a steam heating plant at 518 Walnut St. for the Atlas Natl. Bank, Walnut St. About $500,000.

O., Cleveland—The Bd. Educ., East 6th St. and Rockwell Ave., will receive bids until May 15 for a 2 story, 65 x 245 ft. addition to high school on Scranton Rd. and Castle Ave., to include a 1 story, 50 x 60 ft. boiler house with two heating boilers. About $400,000. W. R. McCormack, East 6th St. and Rockwell Ave., Archt.

O., Cleveland—The Cleveland Railway Co., Hanna Bldg., plans to build several 1 story automatic sub-stations at various locations. About $60,000 each. L. P. Bale, Hanna Bldg., Engr.

O., Columbus—The Childrens Hospital, F. O. Schoedinger, Chn., is receiving bids for a 4 story childrens hospital including refrigerator plant. Cost between $350,000 and $400,000. R. McVarty & Bueford, 584 East Broad St., Archts.

Okla., Thomas—The city is having surveys made for the installation of pumping plant and wells. About $50,000. H. G. Olmstead, 415 Oil Exchange Bldg., Oklahoma City, Engr.

Pa., Grove City—The city Light Comrs. plans an addition to municipal light plant including the installation of an oil engine and dynamo.

Pa., Phila.—The Bureau of Yards and Docks, Navy Dept., Wash., D. C., plans heating plant building. Estimated cost, $30,000. Spec. 4628.

Pa., Pittsburgh—H. R. Eicher, House Bldg., is in the market for a 200 hp. H. R. T. butt strapped, triple riveted boiler complete with stack front, grate bars, pump and fittings, (used).

Tenn., Nashville—The Bd. Public Wks. will receive bids until May 9 for Division A: two 1,500 kw. (1,875 kva. at 80 per cent power factor) steam turbine generator units; one 500 kw. (625 kva. at 80 per cent power factor) steam turbine generator unit; Division E, 12 constant current transformers; Division F, switchboard and accessories, to be installed in the City Light Plant, S. H. McKay, Clk.

Tex., Paris—The city council, J. M. Crook, Mayor, will receive bids until May 16 for impounding and storage dam, involving 260,000 cu.yd. embankment and 6,000 cu.yd. cyclopean masonry in spillway and headworks, rapid sand filtration plant with four 750,000 gal. units, 3 of which will be fully equipped; attached to filter plant will be pumping plant housed in same building, bids considered in sections as follows: (a) filter building, pumphouse, clear well, mixing chamber, coagulation sedimentation basin with appurtenances, (b) filter equipment, (c) pumping machinery, 2,200 ton 20 in. c.i. pipe class A and C, 20 ton special castings, etc., 22,000 ft. 20 in. supply main from filtration plant to city, 500,000 gal. steel tank on 100 ft. steel tower, 30 ft. steel tower. $1,000,000 bond issue available. M. C. Welborn, City Engr.

Va., Yorktown—The Bureau of Yards and Docks, Navy Dept., Wash., D. C., plans remodeling 3 Diesel oil engines.

W. Va., Rouceverte—The Virginia Western Power Co., Clifton Forge, plans addition to power plant. Total cost including machinery and equipment, and line extensions, $500,000.

Wis., Blue Mounds—The village, P. Brazer, Clk., plans to build a reservoir and install equipment for furnishing water. About $10,000. Engineer not selected.

Wis., Madison—The Madison Sanitarium, c/o P. Larson, is receiving bids for equipment for power house and pumping house.

Wis., Milwaukee—The Milwaukee Western Fuel Co., 120 Wisconsin St., is having plans prepared for coal hoppers including the installation of coal conveying machinery at the Foot of 18th St. About $16,000. J. Eckes, Engr.

Wis., Neshonoc—The Neshonoc Power Co., c/o E. C. Swarthout, Rose St., La Crosse, plans to build a dam, 160 ft. long, 18 ft. high, waterwheel, generator, remodel and install equipment in power house. About $35,000. W. S. Woods, La Crosse, Engr.

Wyo., Basin—The city, R. B. West, Mayor, plans election to vote $60,000 bonds for purchasing and installing additional machinery in the city power plant and for the construction of an additional settling basin and purifying plant to provide town with water. D. C. Loyer, Clk.

Ont., Kingston—The Ontario Prov. Govt., Dairy School, Dept. of Agriculture, Toronto, plans to build a 2 story dairy school to include ice and cheese making plant. About $90,000. Prof. L. A. Zufelt, Supt.

Ont., Lindsay—Victoria county is in the market for pile driver, rotary pump, diaphram trench pump, centrifugal pump, mixer, etc. E. L. Miles, County Bldg., Engr.

Ont., St. Catherine—The council will soon receive bids for the construction of a filtration plant including materials and equipment. About $28,000. W. P. Near, City Hall, Engr.

CONTRACTS AWARDED

Cal., Decoto—The Masonic Home of California, c/o W. Mooser and E. G. Bolles, Archts., Nevada Bank Bldg., San Francisco, has awarded the contract for plumbing, heating and electric work for proposed addition to home to O. Kurtz, 445 Stevenson St., San Francisco. Total cost $382,648.

Cal., San Diego—The Bureau of Yards and Docks, Navy Dept., Wash., D. C., has awarded the contract for an electric distributing system at the Naval Base Hospital to W. A. McNalley & Co., 106 West Colorado St., Pasadena, $34,400. Spec. 4610.

Col., Denver—The Super Service Motor Co., 410 Colorado Bldg., has awarded the contract for a 3 story, 115 x 210 ft. service garage on 7th and Speer Blvd. to C. S. Lambie, Tramway Bldg. Cost plus percentage basis. Est. cost $300,000.

Ill., Chicago—The Atwell Printing & Binding Co., Sherman and Polk Sts., has awarded the contract for a 6 story, 170 x 177 ft. printing plant on Prairie Ave. and 20th St. to R. F. Wilson Co., 1851 Elston Ave. About $700,000. Noted April 11. Steam heating system will be installed.

Kan., McCracken—The city, c/o L. L. Ryan, City Clk., Mgr., has awarded the contract for a power plant building to Herman Keuffer, McCracken, $6,700; Switchboards and motors to Fairbanks-Morse, 1304 Liberty St., Kansas City, $28,500. Noted Oct. 11.

Kan., Pratt—The city has awarded the contract for furnishing 5 deep wells and equipment including pumps, motors, piping, etc.; 5 well houses, 8,810 ft. transmission line, cast iron pipe, 1,300,000 gal. elevated pump, one 300 hp. water tube boiler, steam piping complete, switchboard, etc., to the Merkle Machine Co., 1733 Walnut St., Kansas City, $140,150.

Ky., Louisville—The Belknap Hardware & Manufacturing Co., 127 West Washington St., has awarded the general contract for a 12 story, 204 x 282 ft. office and warehouse building also a power plant and bridges to the Struck Constr. Co., Clay and Franklin Sts. About $1,000,000. Power plant will be moved from No. 1 warehouse to new building on a new site corner of Snead and Washington Sts. Will have 1,200 hp. boilers and 800 k.w. turbine generator sets with railroad connections, automatic coal and ash handling machinery.

Mass., Brighton (Boston P. O.)—I. Shapiro, 110 Warren St., will build a 4 story apartment on Elko St. About $350,000. Work will be done by day labor. A steam heating system will be installed.

N. Y., Long Island City—The Queensboro Corp., 50 East 42nd St., New York City, has awarded the contract for the construction of fourteen apartments on 28th St. and Roosevelt Ave., Jackson Heights, to Stone & Webster, 120 Bway., New York City. Total cost about $1,250,000.

N. Y., New York—M. R. Jennings, c/o J. E. R. Carpenter, Archt., 598 Madison Ave., will build an apartment on 5th Ave. and 96th St. About $750,000. Work will be done by separate contract under supervision of Archt.

N. Y., New York—Manger Bros., Hotel Netherlands, 5th Ave. and 59th St., have awarded the contract for a 13 story hotel in vicinity of 30th St. and 7th Ave. to O'Day Constr. Co., 1639 Bway. About $800,000.

N. Y., Wards Island—The State Hospital Comn. has awarded the contract for the construction of an assembly hall and bakery building at the Manhattan State Hospital to Acampora Bros., Builders, Inc., 39 Ward Ave., Mamaroneck, $199,748; heating to Chute, Thornton & Bayley Corp., 153 East 42nd St., $12,788.

N. Y., Warsaw—The Warsaw Gas & Electric Co. has awarded the contract for an 80 x 80 x 104 ft. power house at Rock Glen Salt plant to the Oatka Engr. and Constr. Co. of Warsaw. About $40,000.

Ore., Grants Pass—The Grant Pass Irrigation Dist. has awarded the contract for 12 in. centrifugal pump, 3,600 gal. per min. directed to 125 hp. G. E. motor with automatic compensator and 16 in. pump, 9,000 gal. per min. head 92 ft. 250 hp. G. E. motor, 220 volt, 3 phase, 60 cycle ac. with automatic starter to the DeLaval Steam Turbine Co., Trenton. $5,631. Pipe to Continental Pipe Mfg. Co., Seattle, Wash., $10,396. Noted Nov. 29.

Pa., Phila.—The Cohocksink Amusement Co., c/o Neubauer & Supowitz, 929 Chestnut St., has awarded the contract for a 2 story, 70 x 129 ft. theatre on Germantown Ave. and Diamond St. to G. W. Stewart, 2123 Germantown Ave. About $250,000. Cooling, ventilating and indirect heating system will be installed.

Pa., Phila.—The Locust and Juniper Realty Co., 667 North Broad St., has awarded the contract for a 14 story, 100 x 150 ft. hotel on Juniper and Locust Sts. to J. R. Wiggins & Co., Cherry and 18th Sts.

Pa., Phila.—C. J. MacIlvain, Jr., Otis Bldg., has awarded the contract for a 15 story, 48 x 190 ft. apartment on 18th St. and Rittenhouse Sq. to Metzer; Fisher & White, Otis Bldg. About $6,000,000. A steam heating system will be installed.

Pa., Phila.—The Pennsylvania Apt. Inc., 3904 Chestnut St., will build a 10 story, 140 x 220 ft. apartment and a 2 story, 35 x 108 ft. power house on 39th and Chestnut Sts. About $1,025,000. Owner will build by day labor.

S. C., Charleston—The Francis Marion Hotel Co., Charleston, W. Va., has awarded the contract for a 12 story hotel to J. W. Cowper, Oliver Bldg., Pittsburgh, Pa. About $1,000,000.

Wis., Madison—Oscar Mayer & Co., North St., has awarded the contract for a 1 story, 50 x 75 ft. engine house, etc., on North St., to J. H. Findorff Co., 601 West Wilson St. About $10,000. Equipment will be installed.

B. C., Vancouver—The Granby Consolidated Mining, Smelting & Power Co., 718 Granby St., V. Quinn, Compt., has awarded the contract for multiple arch dam for new reservoir on Falls Creek, maximum height 138 ft. above bed of creek, maximum length 640 ft. to impound 25,000 acre ft. of water to Dredging & Contracting Co., Ltd. About $350,000. Total cost of improvements including laying of pipes to connect with power house, etc., will be about $500,000.

PRICES - MATERIALS - SUPPLIES

Electrical prices on following page are prices to the power plant by jobbers in the larger buying centers east of the Mississippi. Elsewhere the prices will be modified by increased freight charges and by local conditions.

SINCE LAST MONTH

Advances—Steel shapes advanced 10c. per 100 lb. in New York warehouses. Structural and boiler rivets up 15c. in New York; 10c. in Chicago and 10c.@15c. per 100 lb., Pittsburgh. Rise of 15c. in cold finished steel in Cleveland. Raw linseed oil quoted at 91c. as against 82c.@83c. per gal. (5-bbl. lots), New York. Slight advance in 2½-in. common fire hose. Refractories, armored cable and conduit higher.

Declines—Air hose, ¾-in., down 3c.@7c. per ft. Higher discounts on pipe and boiler covering and boiler specialties. Boiler tubes and flexible-drop lamp cords also reduced in New York warehouses.

POWER-PLANT SUPPLIES

HOSE—

	Fire	50-Ft. Lengths
Underwriters' 2½-in.		49½c. per ft.
Common, 2½-in.	80 per ft. list less 50%	

	Air	
	First Grade	Second Grade
¾-in. per ft.	$0.24	$0 19½

Steam—Discounts from List

First grade....40–10% Second grade...50–5% Third grade....50–10–5%

RUBBER BELTING—The following discounts from list apply to transmission rubber and duck belting:

Competition..... 60–10–5% Best grade..... 60–5%

LEATHER BELTING—Present discounts from list in fair quantities (½ doz rolls):

Light Grade	Medium Grade	Heavy Grade
50%	40–5%	35%

RAWHIDE LACING { For cut, best grade, 50–10%, 2nd grade, 60%. For laces in sides, best, 41c. per sq.ft.; 2nd, 39c. Semi-tanned: cut, 50%; sides, 43c. per sq.ft.

PACKING—Prices per pound:

Rubber and duck for low-pressure steam, ¼ in.	$0.90
Asbestos for high-pressure steam, ¼ in.	1.80
Duck and rubber for piston packing	.90
Flax, regular	1.10
Flax, waterproofed	1.70
Compressed asbestos sheet	.90
Wire insertion asbestos sheet	1.30
Rubber sheet	.45
Rubber sheet, wire insertion	.70
Rubber sheet, duck insertion	.50
Rubber sheet, cloth insertion	.30
Asbestos packing, twisted or braided and graphited, for valve stems and stuffing boxes	1.40
Asbestos wick, ½- and 1-lb. balls	.70

PIPE AND BOILER COVERING—Discounts are as follows:

85% magnesia high pressure		60% off
For low-pressure heating and return lines	4-ply	70% off
	3-ply	72% off
	2-ply	74% off

PORTLAND CEMENT—New York, $2.40 per bbl. without bags, in cargo lots delivered on job. Bag charge of 40c. per bbl.

STRUCTURAL STEEL—New York delivered price, 3 to 15-in. beams and channels and 3 to 6-in. angles, tees, and plates, all $2.58 per 100 lb.

COTTON WASTE—The following prices are in cents per pound:

	New York Current	Cleveland	Chicago
White	7.50@10.00	12.00	12.00
Colored mixed	5.50@ 9.00	9.00	9.00

WIPING CLOTHS—Jobbers' price per 1,000 is as follows:

	13½ x 13½	13½ x 20½
Cleveland	$50.00	$55.00
Chicago	55.00	65.00

LINSEED OIL—These prices are per gallon:

	New York	Cleveland	Chicago
Raw in barrels (5 bbl. lots)	$0.91	$0.95	$0.90

WHITE AND RED LEAD—Base price per pound:

	Red				White	
	Current		1 Year Ago		Current	1 Yr. Ago
	Dry	In Oil	Dry	In Oil	Dry and In Oil	Dry and In Oil
100-lb. keg	12.25	13.75	15.50	17.00	12.25	15.50
25- and 50-lb. keg	12.50	14.00	15.75	17.25	12.50	15.75
12½-lb. keg	12.75	14.25	16.00	17.50	12.75	16.00
5-lb. cans	15.25	16.75	18.50	20.00	15.25	18.50
1-lb. cans	17.25	18.75	20.50	22.00	17.25	20.50

RIVETS—The following quotations are allowed for fair-sized orders from warehouse:

	New York	Cleveland	Chicago
Steel ⅞ and smaller	60–5%	60–10–10%	65–5%
Tinned	60–5%	60–10–10%	4½c. per lb. net

Structural rivets, ½ x ½, 1 in. diameter by 2 in. to 5 in. sell as follows per 100 lb.:

New York.....$3.50 Chicago.....$3.10 Pittsburgh $2.10@$2.25

Boiler rivets, same sizes:

New York.....$3.60 Chicago.....$3.20 Pittsburgh $2.20@$2.35

REFRACTORIES—Prices in carlots:

Chrome brick, eastern shipping points	net ton	$42@45
Chrome cement, 40@45% Cr_2O_3	net ton	27@30
Chrome cement, 40@45% Cr_2O_3, in sacks	net ton	29.50@31.50
Magnesite brick: 9-in. straight	net ton	53@55
Magnesite brick: 9-in. arches, wedges and keys	net ton	58.30@60.50
Magnesite brick: Soaps and splits	per ton	74.20@77
Silica brick: Chicago district	per 1,000	35@38
Silica brick: Birmingham, Ala.	per 1,000	40.00
Silica brick: Mt. Union, Pa.	per 1,000	30@33
Chrome ore crude, 45@50%	net ton	20@22
Magnesite dead burn (Imported)	net ton	28@30
Clay brick, 1st quality, 9 in. shapes, Pennsylvania	per 1000	32@35
Clay brick, 1st quality, 9 in. shapes, Ohio	per 1000	32@35
Clay brick, 1st quality, 9 in. shapes, Kentucky	per 1000	32@35
Clay brick, 2nd quality, 9 in. shapes, Pennsylvana	per 1,000	28@32
Clay brick, 2nd quality, 9 in. shapes, Ohio	per 1,000	28@32
Clay brick, 2nd quality, 9 in. shapes, Kentucky	per 1,000	28@32

BABBITT METAL—Warehouse prices in cents per pound:

	New York	Cleveland	Chicago
Best grade	30.80	39.50	36.00
Commercial	15.50	13.50	9.00

COLD FINISHED STEEL—Warehouse prices are as follows:

	New York	Chicago	Cleveland
Round shafting and screw stock, per 100 lb. base	$3.35	$3.30	$3.00
Flats, square and hexagons, per 100 lb. base	3.85	3.80	3.50

BOILER SPECIALTIES—F. o. b. New York or Jersey City, discounts on list:

	Current
Copper ferrules	70%
Boiler flanges	60-10%
Boiler stay bolts	60%
Boiler patch bolts	10%
Boiler fitting-up bolts	60%
Pressed steel boiler lugs	10%
Pressed steel boiler hangers	10%

WROUGHT PIPE—The following discounts are to jobbers for carload lots on the latest Pittsburgh basing card:

	Steel Black	Steel Galv.		Iron Black	Iron Galv
	BUTT WELD				
Inches			Inches		
⅛ to 3	71	58½	¼ to 1½	44½	29½
	LAP WELD				
2	64	51½	2	39½	25½
2½ to 6	68	55½	2½ to 4	42½	29½
7 to 8	65	51½	4½ to 6	42½	29½
9 and 12	64	50½	7 to 12	40½	27½
	BUTT WELD, EXTRA STRONG, PLAIN ENDS				
1 to 1½	69	57½	1 to 1½	44½	30½
2 to 3	70	58½			
	LAP WELD, EXTRA STRONG, PLAIN ENDS				
2	62	50½	2	40½	27½
2½ to 4	66	54½	2½ to 4	43½	31½
4½ to 6	65	53½	4½ to 6	42½	30½
7 to 8	61	47½	7 to 8	35½	23½
9 to 12	55	41½	9 to 12	30½	18½

BOILER TUBES—Following are prices in New York warehouse of tubes manufactured according to specifications of the American Society of Mechanical Engineers:

Size	Lapweld Steel	C. C. Iron	Seamless Steel
1	.....	.....	.15
1¼	.....	.....	.1650
1½	.....	.....	.1411
1¾	$0.1654	$0.1881	.1530
2	.1305	.1607	.1332
2¼	.1491	.1836	.1521
2½	.1566	.2160	.1824
2¾	.....	.....	.....
3	.1916	.2668	.2097
3¼	.2066	.3078	.2253
3½	.2204	.3282	.2403
4	.2800	.4173	.3054

Tubes 2½ in. diameter, or smaller, over 18 ft. long, 10 per cent extra.

These prices are net per lineal foot based on stock lengths. If cut to special engths, billing will be based on the entire stock lengths.

In addition to the above, standard cutting charges are as follows:

1¼ in. to 2 in. diameter, 5c. per cut. 2¾ in. diameter, 7c. per cut
2¼ in. diameter, 6c. per cut. 3 in. diameter, 9c. per cut
3¼ in. to 4 in. diameter, 10c.

ELECTRICAL SUPPLIES

ARMORED CABLE—Price per 1,000 ft.—5 per cent 10 days.

B. & S. Size	Two Cond. M Ft.	Three Cond. M Ft.	Two Cond. Lead M Ft.	Three Cond. Lead M Ft.
No. 14 solid	$ 44.00 (net)	$138.00	$164.00	$210.00
No. 12 solid	135.00	170.00	225.00	265.00
No. 10 solid	185.00	235.00	275.00	325.00
No. 8 stranded	285.00	375.00	520.00	500.00
No. 6 stranded	400.00	500.00	560.00	.....

From the above lists discounts are:

Less than coil lots	30%	10%
Coils to 1,000 ft.	40%	20%
1,000 to 5,000 ft.	41%	22%
5,000 ft. and over	43%	25%

BATTERIES, DRY—Regular No. 6 size red seal, Columbia, or Ever-Ready:

	Each, Net
Less than 12	$0.40
12 to 50	.34
50 to 125 (bbl.)	.30½
125 (bbl.) or over	.29

CONDUIT, Price per 1,000 ft.; **ELBOWS AND COUPLINGS**, Per 100 pieces, f. o. b. New York, with 10-day discount of 5 per cent.

Size, In.	Conduit Black 2,500 to 5,000 Lbs.	Conduit Galvanized 2,500 to 5,000 Lbs.	Elbows Black 2,500 to 5,000 Lbs.	Elbows Galvanized 2,500 to 5,000 Lbs.	Couplings Black 2,500 to 5,000 Lbs.	Couplings Galvanized 2,500 to 5,000 Lbs.
¼	46.58	51.68	9.65	10.97	4.75	5.17
⅜	59.57	66.47	12.70	14.20	6.78	7.38
½	84.66	94.86	12.80	21.02	8.81	9.59
¾	114.54	128.34	25.11	27.81	12.38	13.40
1	136.95	153.45	33.48	37.08	15.29	16.55
1¼	184.26	206.46	61.38	67.98	20.38	22.06
1½	291.33	326.43	100.44	111.24	29.12	31.52
2	380.97	426.87	267.84	296.64	43.68	47.28
2½	485.76	540.96	591.48	655.08	58.24	63.04
3	597.32	662.72	683.55	757.05	72.80	78.80

CONDUIT NON-METALLIC, LOOM—

Size I. D., In.	Feet per Coil	List, Ft.	
⅜	250	$0.05½	⅜ and ½ in. Less 71%
½	250	.06	
¾	250	.09	
1	200	.12	Balance 1000 ft. and over 65%
1¼	200	.15	
1½	150	.18	
2	100	.25	Coils....60%
2½	100	.33	Less coils, 55%
3	Odd lengths	.40	
4	Odd lengths	.55	

CUT-OUTS—Following are net prices each in standard-package quantities:

CUT-OUTS, PLUG

S. P. M. L.	$0.08	D. P. D. B.	$0.26
D. P. M. L.	.13	T. P. S. B.	.25
T. P. M. L.	.19	T. P. D. B.	.38
D. P. S. B.	.15		

CUT-OUTS, N. E. C. FUSE

	0-30 Amp.	31-60 Amp.	60-100 Amp.
D. P. M. L.	$0.38	$1.20	$1.25
T. P. M. L.	.53	1.40	1.80
D. P. S. B.	.47	1.20	.....
T. P. S. B.	.88	2.00	.....
D. P. D. B.	.85	2.35	.....
T. P. D. B.	1.50	4.00	.....
T. P. to D. P. D. B.	1.00	2.75	.....

FLEXIBLE CORD—Price per 1,000 ft. in coils of 250 ft.:

No. 18 cotton twisted	$10.90
No. 16 cotton twisted	13.75
No. 18 cotton parallel	13.00
No. 16 cotton parallel	16.75
No. 18 cotton reinforced heavy	19.00
No. 16 cotton reinforced heavy	24.90
No. 18 cotton reinforced light	16.50
No. 16 cotton reinforced light	20.50
No. 18 cotton Canvasite cord	14.00
No. 16 cotton Canvasite cord	16.25

FUSES, ENCLOSED—

250-Volt	Std. Pkg.	List	600-Volt	Std. Pkg.	List
3-amp. to 30-amp.	100	$.20	3-amp. to 30-amp.	100	$0.40
35-amp. to 60-amp.	100	0.30	35-amp. to 60-amp.	100	.60
65-amp. to 100-amp.	50	2.90	65-amp. to 100-amp.	50	1.50
110-amp. to 200-amp.	25	3.00	110-amp. to 200-amp.	25	2.50
225-amp. to 400-amp.	25	5.60	225-amp. to 400-amp.	25	5.50
425-amp. to 600-amp.	10	.50	450-amp. to 600-amp.	10	8.00

Discount: Less 1-5th standard package, 60%; 1-5th to standard package, 60–5%; standard package, 65–5%.

RENEWABLE FUSES, ENCLOSED—

Sizes	250-Volt List-Price	600-Volt List-Price	Std. Pkg. Quantity	Carton Quantity
1 to 30-amp.	$0.50 ea.	$1.10 ea.	100	10
35 to 60-amp.	1.00 ea.	1.25 ea.	100	10
65 to 100-amp.	2.00 ea.	3.00 ea.	50	5
110 to 200-amp.	4.00 ea.	5.00 ea.	25	5
225 to 400-amp.	7.50 ea.	11.00 ea.	25	1
450 to 600-amp.	11.00 ea.	16.00 ea.	10	1
450 to 600-amp.	11.00 ea.	16.00 ea.	10	1

RENEWAL LINE FOR ABOVE FUSES—

1 to 30	$0.30 ea.	$0.05	100	100
35 to 60	.05 ea.	.06	100	100
65 to 100	.10 ea.	.10	50	50
110 to 200	.15 ea.	.15	25	50
225 to 400	.30 ea.	.30	25	25
450 to 600	.60 ea.	.60	10	10

Discount Without Contract—Fuses:	
Broken carton	5%
Unbroken carton but less than std. pkg.	22%
Std. pkg.	40%
Discount Without Contract—Renewals:	
Less than std. pkg.	Net list
Standard package	40%
Discount With Contract—Fuses:	
Broken cartons	10%
Unbroken cartons but less than standard package	26%
Standard package	42%
Discount With Contract—Renewals:	
Less standard package	Net list
Standard package	42%

FUSE PLUGS, MICA CAP—

0–30 ampere, standard package	$2.40
0–30 ampere, less than standard package	2.75

LAMPS—Below are present quotations in less than standard package quantities:

Straight-Side Bulbs Mazda B— Watts	Plain	Frosted	No. in Package	Pear-Shaped Bulbs Mazda C— Watts	Clear	Frosted	No. in Package
10	$0.35	$0.40	100	75	$0.70	$0.75	50
15	.35	.40	100	100	.95	1.00	24
25	.35	.40	100	150	1.30	1.40	24
40	.35	.40	100	200	1.80	1.90	24
50	.35	.40	100	300	2.50	2.65	24
60	.40	.45	100				12
				500	3.75	3.95	12
				750	5.25	5.50	8
				1,000	6.00	6.35	8

Standard quantities are subject to discount of 10% from list. Annual contracts ranging from $150 to $300,000 net allow a discount of 17 to 40% from list.

PLUGS, ATTACHMENT—

	Each
Porcelain separable attachment plug	$0.17
Composition 2-piece attachment plug	.24
Swivel attachment plug	.12
Current taps	.36

RUBBER-COVERED COPPER WIRE—Per 1000 ft. f. o. b. New York.

No.	Solid Single Braid	Solid Double Braid	Stranded, Double Braid	Duplex
14	$ 6.25	$ 8.00	$ 9.55	$15.20
12	8.30	10.10	11.95	19.85
10	10.90	13.00	15.20	25.80
8	14.65	17.05	20.05	34.50
6	.....	.....	30.30	.....
4	.....	.....	40.90	.....
2	.....	.....	61.90	.....
1	.....	.....	82.70	.....
0	.....	.....	102.65	.....
00	.....	.....	121.80	.....
000	.....	.....	146.35	.....
0000	.....	.....	175.15	.....

SOCKETS, BRASS SHELL—

½ In. or Pendant Cap Key Each	½ In. or Pendant Cap Keyless Each	½ In. or Pendant Cap Pull Each	¾ In. Cap Key Each	¾ In. Cap Keyless Each	¾ In. Cap Pull Each
$0.33	$0.30	$0.60	$0.39	$0.36	$0.66

Less 1-5th standard package	15%
1-5th to standard package	30%
Standard package	45%

WIRE, ANNUNCIATOR AND DAMPPROOF OFFICE—

No. 18 B. & S. regular spools (approx. 8 lb.)	34c. lb.
No. 18 B. & S. regular 1-lb. coils	35c lb

WIRING SUPPLIES—

Friction tape, ¾ in., less 100 lb. 34c. lb., 100 lb. lots	33c. lb
Rubber tape, ¾ in., less 100 lb. 34c. lb., 100 lb. lots	33c. lb
Wire solder, less 100 lb. 27c. lb., 100 lb. lots	21c. lb
Soldering paste, 2 oz. cans	$1.00 doz

SWITCHES, KNIFE—

TYPE "C" NOT FUSIBLE

Size, Amp.	Single Pole, Each	Double Pole, Each	Three Pole, Each	Four Pole, Each
30	$0.42	$0.68	$1.02	$1.36
60	.74	1.22	1.84	2.44
100	1.50	2.50	3.76	5.00
200	2.70	4.50	6.76	9.00

TYPE "C" FUSIBLE, TOP OR BOTTOM

30	70	1.06	1.60	2.12
60	1.18	1.80	2.70	3.60
100	2.38	3.66	5.50	7.30
200	4.50	6.76	10.14	13.50

Discounts:	
Less than $10.00 list value	5%
$10 to $25 list value	20%
$25 to $50 list value	25%
$50 to $200 list value	35%
$200 list value or over	40%